TRANSACTIONS

OF

THE FEDERATED INSTITUTION

OF

MINING ENGINEERS.

VOL. I.—1889-1890.

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FEDERATED INSTITUTION OF MINING ENGINEERS.

NOTICE OF THE PRELIMINARY PROCEEDINGS WHICH LED TO THE FORMATION OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The late Mr. Nicholas Wood in his (the first) presidential address to the North of England Institute of Mining and Mechanical Engineers, on September 3rd, 1852, said that they did not entertain ideas antagonistic to any existing institution, or to the one then proposed to be established in London. He then seemed to forecast the formation of a Federated Institution, as he said their institute would be most happy to co-operate with any other institution or society having for its object the prevention of accidents in mines, and that it was prepared to carefully consider any plan which might be submitted.

In their second annual report the North of England Institute suggested that its advantages might be multiplied and secured by some junction with other societies, pursuing similar objects, but their independence of action must be maintained, without which the federation would become worse than useless.

In May, 1854, a general meeting of representatives from the coal-mining districts was held in London, and a favourable augury was then drawn of the future results of joint efforts in securing the safety and welfare of the persons employed in collieries. This meeting, however, failed to establish a society which should afford a means of communication between the various mining districts, and of enabling each to acquaint itself with the superior or peculiar practices of the others, although it was felt that most valuable consequences would result from such a circulation of the mining knowledge of the country.

Sir George Elliot, in his presidential address to the North of England Institute of Mining and Mechanical Engineers, on November 7th, 1868, directly proposed that an endeavour should be made to amalgamate the various mining institutions of the country, so as to obtain a more general recognition of the importance and value of the profession of a mining engineer. He thought that a national scheme could be evolved, which while preserving the corporate individuality of each institute (which is so valuable), would enable mining engineering to take the highest rank as a scientific profession, and its members to be more highly appreciated. He suggested that the North of England Institute, as the oldest, might take the initiatory steps, and invite the other institutes to meet and discuss the matter with the view of formulating a scheme for their mutual advantage.

Mr. John Daglish in his presidential address to the North of England Institute of Mining and Mechanical Engineers, read on August 7th, 1886, referred to the several schemes which had been mooted for the concentration of the various mining institutes. He considered that any attempt to amalgamate these institutes into one body would be difficult, if not impossible, but thought that a federation confined chiefly to the publication of their Transactions could be carried out to their general advantage. It would place the papers read at each institute in the hands of all

mining engineers, and prevent repetition of papers, and duplication of investigations and experiments by committees on special subjects of general interest. An institute representing the whole of the mining science of Great Britain would be able to supply reliable information to the Government upon the real practical requirements of legislation, and would be a power to resist any proposed legislation contrary to the real interests of mine owners and workmen.

On August 6th, 1887, the late Mr. Theo. Wood Bunning, then Secretary to the North of England Institute of Mining and Mechanical Engineers, read a paper before that institute, pointing out the desirability of establishing an Imperial Mining Institute, to which the existing local mining institutes should be federated. An institution of this kind, if well organized, would prove, he contended, greatly to the advantage of all mining engineers. He pointed out that the existing institutes, although of considerable importance, were provincial associations, with the result that there was not an institution representing mining engineers in their entirety, and that their influence was divided and weak. Their arrangements for publishing were inconvenient, as the Transactions of one society often contained papers that had been read before some of the others, and a mass of useful information was divided and rendered difficult of reference.

London is not a centre of mining industry, yet it contains a large number of mining and metallurgical engineers, and others deeply interested in coal, iron, copper, lead, etc., mines, etc., etc. Mr. Bunning suggested that those gentlemen be approached with the view of their being consolidated into the "London Institute of Mining and Metallurgical Engineers," which should take up the same position towards the Federated Institution of Mining Engineers, as now occupied by the local mining institutes.

Mr. Bunning also suggested that the large body of Englishmen in India and the Colonies, who are interested in mining, etc., and are connected with the local institutes, might be formed into colonial centres, whose papers and discussions might be sent to the Federated Institution for publication.

Mr. Bunning's paper was referred to the consideration of a committee appointed by the North of England Institute of Mining and Mechanical Engineers, with power to consult with the councils of other mining institutes. After the paper had been widely circulated, a representative meeting was held in London, on June 6th, 1888, when the proposals contained in Mr. Bunning's paper were considered. The chairman (Sir Lowthian Bell, Bart.) explained the objects of their meeting, and enumerated the benefits which would arise from such an amalgamation as was proposed Several communications were read from different mining institutes, from which it was evident that the movement was looked upon with favour by the majority of the institutes whose opinions had been invited on the matter. An exhaustive discussion took place as to the best method of inaugurating such a movement, and it was decided that each institute should appoint two of its members as representatives, who should meet and draw up a scheme.

The representatives met at Sheffield on January 30th, 1889, and proposals were considered with reference to the publication of papers, initiation of experimental research, communications with the Government in cases of contemplated legislative action of a scientific character having interest to or affecting mining, etc., and a scheme was proposed detailing the working of a Federated Institution. The representatives agreed to recommend the federation of the mining institutes for these purposes and that a general council should be appointed by the local mining institutes with power to appoint their president, vice-presidents, and officers to manage the business of the Federated Institution.

The institutes then desirous of joining the Federated Institution were :—

The Chesterfield and Midland Counties Institution of Engineers;
The Midland Institute of Mining, Civil and Mechanical Engineers;
The North of England Institute of Mining and Mechanical Engineers;
The North Staffordshire Institute of Mining and Mechanical Engineers; and
The South Staffordshire and East Worcestershire Institute of Mining Engineers.

The details of the proposals for the formation of a Federated Institution were drafted and considered by the representatives at a further meeting in London, on March 14th, 1889, and the bye-laws were formulated and recommended for adoption.

The proposed bye-laws were adopted by the following institutes :—

The Chesterfield and Midland Counties Institution of Engineers;
The Midland Institute of Mining, Civil, and Mechanical Engineers;
The North of England Institute of Mining and Mechanical Engineers; and
The South Staffordshire and East Worcestershire Institute of Mining Engineers;

And the Federated Institution of Mining Engineers was accordingly founded by mutual agreement of these institutes, as and from July 1st, 1888.

FEDERATED INSTITUTION OF MINING ENGINEERS.

BYE-LAWS.

1.—The name of the Federation shall be "THE FEDERATED INSTITUTION OF MINING ENGINEERS."

2.—The objects of the Federated Institution of Mining Engineers are as follows:—(A) Publishing; (B) Appointment of Committees for experimental research; (C) Communication with the Government in cases of contemplated legislative action of a scientific character that interests or affects mining.

3.—Members shall be subscribers and Honorary Members of the Federated Institutes (see clauses 11 and 15).

4.—A Council shall be elected annually as the General Council of the Federated Institution by and out of each Institute in the proportion of one member of Council to fifty members of the Institutes. The Council shall, at their meeting, proceed to add ten gentlemen to their number, to be selected from each Federated Institute in the same proportion.

5.—A President of the Federated Institution shall be elected each year at the Annual General Meeting, and shall not be eligible for re-election for one year.

6.—Each President shall continue during membership of one of the Federated Institutes an *ex-officio* member of the Council.

7.—One Vice-President shall be elected by and from the Council for each district for each 200 Associated Members.

8.—The Council shall appoint from its number a Committee of Selection of papers for publication. Such Committee to consist of one representative from each Institute, the selection subject to approval of the Council.

9.—The Council shall be empowered to frame, from time to time, Bye-Laws for the proper carrying out of the objects of the Federation.

10.—General Meetings shall be held in one of the affiliated districts in January, July, and September, and an Annual General Meeting shall be held in London in April in each year.

11.—Each Associated Member shall have access to, and take part in, the General Meetings of the individual Institutes and of the Federated Institution. He shall also receive the Transactions and Proceedings of the Federated Institution.

12.—A discussion shall be opened *pro formâ* in each district on each paper, and, if thought necessary, a special discussion may be called for by the President of any district where an important discussion is likely to arise, and the author shall be invited to attend. The final discussion at the Institute where the paper has been read shall be deferred until all the other discussions are closed, so that the author may be able to reply to all.

13.—Publications:—These shall be in two forms, viz.:—(A) *Transactions:* Comprising important papers having permanent interest; and (B) *Proceedings:* Cheaper form of publication similar to the bulletins of the "Société de l'Industrie Minérale" for the remaining papers.

14.—The discussions shall be printed in the "Proceedings," unless important new matter is introduced which may be published in the "Transactions," at the discretion of the Federated Council.

15.—Each of the Federated Institutes shall pay 15s. per Associated Member into a General Fund to defray the expenses of publication and of the Federation. But the local Institutes shall receive copies of their own portions of the publications in respect of such of their members as do not become members of the Federated Institution, and shall pay 10s. 6d. to the Federated Institution in respect of each such non-Associated Member.

16.—The Secretary of each Institution shall edit the papers of that Institute.

17.—As it may be necessary to have one responsible General Editor, that Professor Lebour be appointed Honorary Secretary and Editor for one year.

18.—The Federated Institution shall commence on the 1st July, 1889.

FEDERATED INSTITUTION OF MINING ENGINEERS.

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ARCHER, JOSEPH, Queen Insurance Buildings, Church Street, Sheffield.
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AUDUS, T., Mineral Traffic Manager, Neville Hall, Newcastle-on-Tyne.

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BAILEY, SAMUEL, 30, Waterloo Street, Birmingham.
BAILEY, S. and J., 30, Waterloo Street, Birmingham.
BAIN, R. DONALD, H.M. Inspector of Mines, 85, Pembroke Road, Clifton, Bristol.
BAINBRIDGE, EMERSON, Nunnery Colliery Offices, Sheffield.
BAKER, GODFREY, Cromford Road, Ripley, Derby.
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BANCROFT, ROBERT E., Tivoli, Sefton Park, Liverpool.
BANKS, THOMAS, 60, King Street, Manchester.
BARBER, THOMAS, Lamb Close House, Eastwood, Notts.
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BELK, WILLIAM JAMES, Thorncliffe Collieries, Chapeltown, Sheffield.
BELL, C. E., Park House, Durham.
BELL, GEO. FRED., H.M. Inspector of Mines, 4, St. Thomas' Square, Newcastle-on-Tyne.
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BENSON, T. W., 11, Newgate Street, Newcastle.
BENTON, Prof. W. E., 63, Pitt Street, Sydney, New South Wales.
BERKLEY, C., Marley Hill, Whickham, R.S.O., Co. Durham.
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Blagburn, Charles, 150, Leadenhall Street, London, E.C.
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*Cavendish, Lord Edward, M.P., Chatsworth, Chesterfield.
Chalmers, George, Superintendent of the St. John del Rey Mining Co., 28, Tower Chambers, Finsbury Pavement, London, E.C.
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Chambers, John, 43, Liverpool Street, King's Cross, London, W.C.
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Cheesman, W. T., Wire Rope Manufacturer, Hartlepool.
Chester, P. M., Oakwell Colliery, Ilkeston.
Chicken, Lancelot W., Boldon Colliery, Co. Durham.
Childe, Henry S., Mining Engineer, Wakefield.
Clamp, Elijah, Birch Coppice Colliery, near Tamworth.
Clark, C. F., Garswood Coal and Iron Co., Limited, near Wigan.
Clark, John, The Grove, Aldercar, Langley Mill, Notts.
Clark, R. B., Springwell Colliery, Gateshead.
Clark, W. F., Rowley Station Colliery, Dudley.
Clarke, E. B., 38, Norfolk Street, Sheffield.
Clarke, James A., Ayr Colliery, Annbank, N.B.
Clarke, R. W., Wharncliffe Silkstone Colliery Barnsley.

*Clarke, W., Victoria Engine Works, Gateshead.
Claughton, G. H., The Priory, Dudley.
Clay, S. E., Venezuelan Austin Gold Mining Co., Limited, Dashwood House, 9, New Broad Street, London, E.C.
Clayton, C. D., Doncaster.
Clough, James, Willow Bridge, Choppington, Morpeth.
Cobbold, C. H., Wentworth Castle, Barnsley.
Cochrane, B., Aldin Grange, Durham.
Cochrane, C., Green Royde, Pedmore, near Stourbridge.
Cochrane, Napier, Aldin Grange, Durham.
Cochrane, R. D., Hetton Colliery Offices, Fence Houses.
Cochrane, W., St. John's Chambers, Grainger Street West, Newcastle-on-Tyne.
Cockburn, W. C., 1, St. Nicholas' Buildings, Newcastle-on-Tyne.
Cockin, T. H., Tinsley Park Colliery, Sheffield.
Cockson, Charles, Ince Coal and Cannel Co., Ince, Wigan.
Coke, G. E., 65, Station Street, Notts.
Cole, Colin, De Beers Mine, Kimberley, South Africa.
Cole, Robert Heath, Endon, Stoke-on-Trent.
Collis, W. B., Swinford House, Stourbridge, Worcestershire.
Colquhoun, T., West Stanley Colliery, Co. Durham.
*Colver, J. C., Eckington Colliery, Chesterfield.
Cook, J., Washington Iron Works, Washington, Co. Durham.
Cooksey, J., West Bromwich.
Cooksey, J. H., West Bromwich.
Cooper, R. W., Solicitor, Newcastle-on-Tyne.
Cooper, S. J., Mount Vernon, Barnsley.
Corbett, V. W., Chilton Moor, Fence Houses.
Corbitt, M., Wire Rope Manufacturer, Teams, Gateshead.
Cotterell, O. J., 16, Bank Street, Sheffield.
Coulson, F., 10, Victoria Terrace, Durham.
Coulson, W., No. 1, Pimlico, Durham.
Coulthard, Francis, Arica Villa, Fox Houses, Whitehaven.
Cox, J. H., 10, St. George's Square, Sunderland.
Cox, L. C., Ravenstone, Ashby-de-la-Zouch.
Coxe, E. B., Drifton, Jeddo, P.O. Luzerne Co., Penns., U.S.A.
Cradock, G., Rope Works, Wakefield.
Craik, T., Church Street, Barnsley.
Craven, Hiram, Jun., Mechanical Engineer, Sunderland.
Craven, John, Westgate Common, Wakefield.
Crawford, James Mill, Murton Colliery, near Sunderland.
*Crawford, W., M.P., North Road, Durham.
Crawshaw, C. B., The Collieries, Dewsbury.
Crawshay, E., Gateshead-on-Tyne.
Crawshay, G., West House, Tynemouth.
Creswick, W., Sharlestone Colliery, Normanton.
Crighton, John, Messrs. Lehicle and Co., Pollard Street East, Manchester.
Crompton, George, Stanton Hall, Nottingham.
Crone, E. W., Forest Hall, near Newcastle-on-Tyne.
Crone, F. E., Seaton Burn Colliery, Newcastle-on-Tyne
Crone, J. R., Tudhoe House, *via* Spennymoor.
Crone, S. C., Forest Hall, Newcastle-on-Tyne.

CROOKES, ARTHUR, The Mount, Eckington, Rotherham.
CROSS, JOHN, 77, King Street, Manchester.
CROSS, W. ASSHETON, Messrs. R. and W. Hawthorn, Newcastle-on-Tyne.
CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, North Wales
CROUDACE, JOHN, West House, Haltwhistle.
CROUDACE, THOMAS, Lambton Lodge, New South Wales.
CURRY, W. THOS., Chelvey, West Town, R.S.O., Somerset.

DACRES, THOMAS, Dearham Colliery, *via* Carlisle.
DAGLISH, JOHN, Rothley Lake, Cambo, R.S.O., Northumberland.
DAGLISH, W. S., Solicitor, Newcastle-on-Tyne.
DAKERS, W. R., Croxdale Colliery, Durham.
DALE, DAVID, West Lodge, Darlington.
*D'ANDRIMONT, T., Liège, Belgium.
DANIEL, W., Steam Plough Works, Leeds.
DARLING, FENWICK, South Durham Colliery, Darlington.
DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales.
DAVEY, HENRY, 3, Princes Street, Westminster, London, S.W.
DAVIES, Lt.-Col. JASPER G. S., R.E., Marton, Middlesbrough.
DAVIES, JOHN, Hartley House, Coundon, Bishop Auckland.
DAVIES, WATKIN, Sheepbridge Iron Works, Chesterfield.
DAVIS, HENRY, All Saints Works, Derby.
DAVIS, KENNETH MCRAE, Dudley Colliery, Northumberland.
DAVIS, W. J., Bradley, near Bilston.
DAVY, GEORGE, Eckington Collieries, Rotherham.
DAY, J. H., The Laurels, Bull Bridge, Ambergate, Derby.
DEACON, MAURICE, Blackwell Collieries, Alfreton.
DEES, J. GIBSON, Floraville, Whitehaven.
DEES, R. R., Solicitor, Newcastle-on-Tyne.
DENNISTON, ROBERT B., Stuart Street, Dunedin, New Zealand.
DEVONSHIRE, THE DUKE OF, K.G., Chatsworth, Chesterfield.
DIAMOND, JAMES, Pye Bridge, Alfreton.
DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea.
DIXON, JAMES S., 97, Bath Street, Glasgow.
DIXON, NICH.
DIXON, R., Wire Rope Manufacturer, Teams, Gateshead.
DOBINSON, LANCELOT, Victoria Coal Company, Park Hills Colliery, near Wakefield.
DODD, B., Bearpark Colliery, near Durham.
DODD, M., Burncroft, Hexham.
DONKIN, W., Warora Colliery, Wardha Coal State Railway, C. P., India.
DOUGLAS, A. S., Hucknall Torkard Colliery, Nottingham.
DOUGLAS, C. P., Parliament Street, Consett, Co. Durham.
DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland.
DOUGLAS, M. H., Usworth Colliery, Washington Station.
DOUGLAS, T., The Garth, Darlington.
DOWDESWELL, H., Butterknowle Colliery, *via* Darlington.
DOYLE, PATRICK, Indian Engineering, 19, Lall Bazar, Calcutta, India.
DRAPER, W., New Seaham Colliery, Sunderland.
DUNN, A. F.
DURHAM, EARL OF, Lambton Offices, Fence Houses.
DURNFORD, H. S., Swaithe Main Colliery, Barnsley.

DUTSON, JOHN, Orgreave Colliery, near Sheffield.
*DYSON, GEORGE, Middlesbrough.
DYSON, W. H., Eckington Collieries, Rotherham.

EAMES, W., Netherseal Colliery, Burton-on-Trent.
EARDLEY, EDWIN, No. 6, The Gables, Uttoxeter New Road, Derby.
EARDLEY, J. W., The Old Vicarage, Alfreton.
EASTWOOD, EDWARD, J.P., Railway Wagon Works, Chesterfield.
EASTWOOD, G. A., Tapton Villa, Chesterfield.
EATON, JOHN, Cliff House, Clowne, Chesterfield.
EDEN, C. H., Old Etherley, *via* Darlington.
EDGE, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop.
EDWARDS, F. H., Forth House, Bewick Street, Newcastle-on-Tyne.
ELCE, GEORGE, Clayton-le-Moors, Accrington, Lancashire.
ELEY, J. J., Snydale Colliery, near Pontefract.
ELLIOT, Sir GEORGE, Bart., M.P., D.C.L., 1, Park Street, Park Lane, London, W.
ELLIS, W. R., Wigan.
ELSDON, ROBERT, The Highlands, Burnt Ash Hill, Lee, Kent.
ELWEN, THOMAS LEE, Littleburn Colliery, near Durham.
EMBLETON, T. W., The Cedars, Methley, Leeds.
EMBLETON, T. W., Jun., The Cedars, Methley, Leeds.
EMINSON, J. B., Londonderry Offices, Seaham Harbour.
ERSKINE, Capt., W. C. C., Inspector of Mines, Kimberley, South Africa.
EVERARD, J. B., 6, Millstone Lane, Leicester.

FAIRLEY, JAMES, Craghead and Holmside Colliery, Chester-le-Street.
FAIRLEY, W., Beau Desert, Rugeley.
FARMER, A., Seaton Carew, near West Hartlepool.
FARNWORTH, W., Swindon, near Dudley, Worcestershire.
FARRAR, JAMES, Old Foundry, Barnsley.
FARROW, JOSEPH, Brotton Mines, Brotton, R.S.O.
FAVELL, T. M., Etruria Iron Works, near Stoke-on-Trent
FEARN, J. W., Devonshire Street, Chesterfield.
FELLOWS, J. M., Pensnett, near Dudley.
FENWICK, BARNABAS, 84, Osborne Road, Newcastle-on-Tyne.
FENWICK, T. E., Mayfield, Wolsingham, near Darlington.
FERENS, FREDERICK J., Silksworth Colliery, Sunderland.
FERENS, ROBINSON, Oswald Hall, near Durham.
FERGUSON, D., The Persian Bank Mining Rights Corporation, Limited, 6, Drapers' Gardens, London, E.C.
FINCKEN, C. W., Hoyland Silkstone Colliery, Barnsley.
FIRTH, J., Hunslet New Road, Leeds.
FIRTH, W., Water Lane, Leeds.
FISHER, ED. R., Nant Glas, Cross Hands, near Llanelly, South Wales.
FISHER, HENRY, Clifton Colliery, Nottingham.
FITZWILLIAM, THE RIGHT HON. EARL, K.G., Wentworth Woodhouse, Rotherham.
FLEMING, C. E., Black, Hawthorn, and Co., Gateshead-on-Tyne.
FLETCHER, HERBERT, J.P., The Hollins, Bolton.
FLETCHER, H., Ladyshore Colliery, Little Lever, Bolton, Lancashire.
FLETCHER, JAS., Manager, Co-operative Collieries, Wallsend, near Newcastle, New South Wales.

Fletcher, John, Rock House, Ulverstone.
Fletcher, Lancelot, Brigham Hill, Carlisle.
Fletcher, W., Brigham Hill, *via* Carlisle.
Foggin, W., North Biddick Colliery, Washington Station, Co. Durham.
Forrest, B. J., Villa Maria, Province of Cordoba, Argentine Republic.
Forrest, J. C., Witley Coal Co., Limited, Halesowen, Birmingham.
Forster, C. W., 6, East Parade, Newcastle-on-Tyne.
Forster, G. B., M.A., North Jesmond, Newcastle-on-Tyne.
Forster, G. W., Heworth Colliery, near Newcastle-on-Tyne.
Forster, J. R., Water Company's Office, Newcastle-on-Tyne.
Forster, J. T., Burnhope Colliery, near Lanchester, Co. Durham.
Forster, J. W., 24, Silksworth Terrace, New Silksworth, Sunderland.
*Forster, R., Shincliffe Hall, near Durham.
Forster, T. E., North Jesmond, Newcastle-on-Tyne.
Foster, F. W., Silksworth Colliery, Sunderland.
Foster, George, Osmondthorpe Colliery, Leeds.
Fowler, George, Basford Hall, Nottingham.
France, Francis, St. Helens Colliery Co., Limited, St. Helen's, Lancashire.
Fryar, J. W., Seghill Colliery, Seghill, Northumberland.
Fryar, Mark, Denby Colliery, Derby.

Galloway, T. Lindsay, M.A., Argyll Colliery, Campbeltown, N.B.
Galloway, W., Mining Engineer, Cardiff.
Gallwey, A. P., c/o Ed. Chester, Esq., Box 138, Post Office, Johannesburg, Z.A.R.
Garforth, W. E., West Riding Colliery, Normanton.
*Garland, H., Netherwood Hall, Wombwell, Barnsley.
Gascoyne, Rowland, Mapperley Collieries, Derby.
Geddes, George H., 142, Princes Street, Edinburgh.
Gerrard, James, 19, King Street, Newsham Buildings, Wigan.
Gerrard, John, Inspector of Mines, Westgate, Wakefield.
Gibbons, J. L., 23, Darlington Street, Wolverhampton.
Gilchrist, J. R., Wharncliffe Silkstone Collieries, near Barnsley.
Gill, Thomas, Car House Colliery, Rotherham.
Gillett, F. C., 20, Midland Road, Derby.
Gillett, L. F., 163, Osmaston Road, Derby.
Gillot, J. W., Summer Lane, Barnsley.
Gilroy, G., Woodlands, Parbold, near Wigan.
Gilroy, S. B., Mining Engineer, Nuneaton.
Gjers, John, 3, Southfield Villas, Middlesbrough.
Glennie, W. H., 3, Gordon Place, Erdington, Birmingham.
*Goddard, F. R., Accountant, Newcastle-on-Tyne.
*Gosman, Fred., Mining Institute, Newcastle-on-Tyne.
*Grace, E. N., Dhadka, Asansol, Bengal, India.
Grainger, James, Woollaton, Nottingham.
Gratton, R. T., Knifesmith Gate, Chesterfield.
Grazebrook, A. W., Queen Cross, Dudley, Worcestershire.
Greaves, J. O., St. John's, Wakefield.
Green, J. T., Mining Engineer, Ty Celyn, Abercarne, Newport, Mon.
Greener, Henry, South Pontop Colliery, Annfield Plain.
Greener, John, General Manager, Vale Colliery, New Glasgow, Pictou, Nova Scotia.

Greener, T. Y., West Lodge, Crook, Darlington.
Greensmith, Johnson, Newstead Colliery, Nottingham.
Greenwell, G. C., Elm Tree Lodge, Duffield, Derby.
Greenwell, G. C., Jun.. Poynton near Stockport.
Greenwood, Prof. W. H., Portland Road, Edgebaston, Birmingham.
Gresley, W. S., Reed House, Erie, Pa., U.S.A.
Grey, C. G., 20, Northbrook Road, Leeson Park, Dublin.
Griffith, N. R., Wrexham.
Griffiths, F., Pensnett, near Dudley.
Grimshaw, E. J., 23, Hardshaw Street, St. Helen's, Lancashire.
Guthrie, James K., Eltringham Colliery, Prudhoe, R.S.O.
Guthrie, Reginald, Neville Hall, Newcastle-on-Tyne.
Guy, John George, 8, South Terrace, Job's Hill, Crook, R.S.O., Co. Durham.

Habershon, M. H., Thorncliffe Ironworks and Collieries, near Sheffield.
Haddock, W. T., Jun., Ryhope Colliery, Sunderland.
Hadfield, R. A., Hecla Steel Foundry, Sheffield.
Haggie, Douglas, Thorncliffe Iron Works, Sheffield.
Haggie, D. H., Wearmouth Patent Rope Works, Sunderland.
Haggie, F. W., Gateshead-on-Tyne.
Haggie, G. A., Wearmouth Ropery, Sunderland.
Haggie, Peter Sinclair, Gateshead-on-Tyne.
Hague, Ernest, Castle Dyke, Sheffield.
Hague, W. B., Alma Collieries, Clay Cross, Chesterfield.
Haines, J. Richard, Adderley Green Colliery, near Longton, Stoke-on-Trent.
Hall. Edgar, Wharncliffe Silkstone Colliery, Barnsley.
Hall, Fred. W., Durham Road, Leadgate, Co. Durham.
Hall, George, Brassington Street, Clay Cross, Chesterfield.
Hall, John, Sheepbridge Works, Chesterfield.
Hall, J. C., Pegswood Colliery, near Morpeth.
Hall, L. J., Furness Vale, Stockport.
Hall, M., Lofthouse Station Collieries, near Wakefield.
Hall, M. S., 8, Victoria Street, Bishop Auckland.
Hall, Tom, Haswell Colliery, Haswell, *via* Sunderland.
Hall, Wm., Murton Colliery, *via* Sunderland.
Hall, W. F., Haswell Colliery, Haswell, *via* Sunderland.
Hallas, G. H., Wigan and Whiston Coal Co., Limited, Prescot.
Hallimond, W. Tasker, Estate Manager, Randt Coal Mining and Land Co., Limited, P.O. Box 506, Johannesburg, Z.A.R.
Halse, Edward, 15, Clarendon Road, Notting Hill, London, W.
Hamilton, E., Rig Wood, Saltburn-by-the-Sea.
Hamilton, G., Bulli Coal Mining Co., Sydney, N.S.W.
Hamilton, J. P., c/o Mrs. Hamilton, 34, Cadogan Terrace, London, S.W.
Hancock Thomas, Bagnall House, Nottingham.
Hann, Edmund, Aberaman, Aberdare.
Hansell. R. A., c/o F. L. Hansell and Co., Watson Road, Sheffield.
Harbottle, W. H., Orrell Coal and Cannel Co., near Wigan.
Hardwick, F. K., Eckington Collieries, Rotherham.
Hare, Samuel, Bedlington Collieries, Bedlington, R.S.O., Northumberland.
Hargreaves, J., Rothwell Haigh Colliery, Leeds.
Hargreaves, William, Rothwell Haigh, Leeds.

HARKER, WM., 17A, Great George Street, Westminster, London, S.W.
HARLE, RICHARD, Browney Colliery, Durham.
HARLE, WILLIAM, Pagebank Colliery, near Durham.
HARPER, J. P., All Saints' Chambers, Derby.
HARRIS, W. S., Kibblesworth, Gateshead-on-Tyne.
HARRISON, GEORGE, High Park Colliery, Greasley, Nottingham.
*HARRISON, R., Eastwood, near Nottingham.
HARRISON, R. W.
HARRISON, W. B., Brownhills Collieries, near Walsall.
HASWELL COAL CO., Haswell Colliery Haswell, *via* Sunderland.
HAWKES, J., Heathfield Road, Handsworth, Birmingham.
HAY, J., Jun., Widdrington Colliery, Acklington.
HAY, WILLIAM, Nostell Colliery, Wakefield.
HAY, W., Jun., Wood View House, Stanton, Burton-on-Trent.
HAYNES, FRANK, Birley Collieries, Sheffield.
HAYWARD, W. J., Tipton.
HEAD, JEREMIAH, Queen's Square, Middlesbrough.
HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent.
HEDLEY, J. J., Derwent Cote House, Lintz Green Station.
HEDLEY, J. L., Inspector of Mines, 1, Lovaine Crescent, Newcastle-on-Tyne.
HEDLEY, T. F., Jun., Valuer, Sunderland.
HEDLEY, SEPT. H., Bank Chambers, Wakefield.
HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne.
HENDERSON, C. W. C., The Riding, Hexham.
HENDERSON, H., Pelton Colliery, Chester-le-Street.
HENDY, J. C. B., Pleasley Colliery, Mansfield, Notts.
HENSHAW, A. MAYON, Talk-o'-th'-Hill Colliery, Stoke-on-Trent.
HEPBURN, T., South Street, Langley Park, Durham.
HEPPELL, T., Leafield House, Birtley, Chester-le-Street.
HEPPLEWHITE, W. H., H.M. Inspector of Mines, Roscius House, Corporation Oaks, Nottingham.
HESLINGTON, ALFRED, New Tupton, Chesterfield.
HESLOP, C., Upleatham and Lingdale Mines, Upleatham, R.S.O., Yorkshire.
HESLOP, GRAINGER, Deptford Hall, Sunderland.
HESLOP, JAMES, Sherwood, Nottingham.
HESLOP, SEPTIMUS, Belrooi Colliery, Sitarampur, E. I. R., Bengal, India.
HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington.
HETHERINGTON, D., Greenfield Terrace, Newcastle-on-Tyne.
HETTON COAL COMPANY, Fence Houses.
HEWISON, J. G., New Brimington, Chesterfield.
HEWITT, GEORGE, Unstone, Sheffield.
HEWITT, G. C., Coal Pit Heath Colliery, near Bristol.
HEWITT, H. R., H.M. Inspector of Mines, 47, Hartington Street, Derby.
HEWITT, T. P., Aldwarke Main Colliery, Rotherham.
HEWLETT, A., Haseley Manor, Warwick.
HICKS, Prof. W. M., Firth College, Sheffield,
HIGSON, JACOB, Messrs. J. and P. Higson, 18, Booth Street, Manchester.
HIGSON, JOHN, Oak Bank, Lancaster Road, Eccles, Manchester.
HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear.
HILTON, J., 72, Hawkshead Street, Southport.
HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan.

HINCHLIFFE, J., Bullhouse Colliery, Penistone, near Sheffield.
HODGKINSON, ALBERT, The Laurels, Woollaton, Nottingham.
HODGSON, J., Edmondsley Colliery, Newcastle-on-Tyne.
HOLDING, WILLIAM, Cossall Colliery, Nottingham.
HOLDSWORTH, THOMAS, Clay Cross, Chesterfield.
HOLFORD, W. D., Whittington, Chesterfield.
HOLLIDAY, MARTIN F., Langley Grove, Durham.
HOLLIDAY, T., Hutton Henry Colliery, Wingate, Durham.
HOLLIS, HENRY WM., North Lodge, Darlington.
*HOLME, JAMES, Engineer s Department, Canadian Pacific Railway, Winnipeg, Canada.
HOLMES, C., Grange Hill, near Bishop Auckland.
HOLT, FRANCIS, Midland Railway Locomotive Department, Derby.
HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent.
HOOD, A., 6, Bute Crescent, Cardiff.
HOOPER, ED., c/o J. H. Hooper, College Precincts, Worcester.
HOPE, GEORGE, Success House, Fence Houses.
HOPKINS, EDWARD, Weardale Place, St. John's Chapel.
HOPKINSON, HENRY, Station Street, Nottingham.
HOPPER, J. I., Wire Rope Manufacturer, Tyne Dock, South Shields.
HORNSBY, H.
HORSLEY, W., Whitehill Point, Percy Main, Newcastle-on-Tyne.
HOSKOLD, H. D., Inspector-General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Casilla, Correos, 900, Buenos Ayres.
HOUFTON, CHARLES, Heathfield Villas, Garforth, Leeds.
HOUFTON, J. P., Bolsover Colliery, Chesterfield.
HOWARD, WALTER, Minas Schwager, Coronel, Chili.
HOWARD, WALTER.
HOWARD, W. F., 13, Cavendish Street, Chesterfield.
HOWDEN, THOMAS, Ironfounder, Wakefield.
*HOWE, GEORGE, Clay Cross, Chesterfield.
HOWE, WM., Clay Cross, Chesterfield.
HUBBERSTY, H. A., J.P., Burbage, Buxton.
HUGHES, H. W., Priory Farm House, Dudley, Worcestershire.
HUGHES, J., Dudley.
HUGHES, THOMAS GEORGE, Blackwell, Alfreton.
HUMBLE, JOHN, West Pelton, Chester-le-Street.
HUMBLE, JOSEPH, Markham Collieries, Duckmanton, Chesterfield.
HUNTER, J.
HURST, GEORGE, 58, Eldon Street, Newcastle-on-Tyne.
*HURST, T. G., Osborne Road, Newcastle-on-Tyne.
HUTCHINSON, T. C., Hilda House, Middlesbrough.
HUTT, E. H., Holdfast Main Reef Gold Mining Co., Limited, Boksburg, Z.A.R.
HUTTON HENRY COAL COMPANY, LIMITED, 7, Bondgate, Darlington.

INGHAM, E. T., Blake Hall, Mirfield, *via* Normanton.
IRVINE, JOSEPH R., Hendon Ropery, Sunderland.

JACKSON, A., Howley Park Colliery, Batley.
JACKSON, C. G., Anderton Hall, near Chorley.

Jackson, John, Stubben Edge, Chesterfield.
Jackson, W. B. M., Clay Cross Hall, Chesterfield.
Jackson, W. G., Hicklam House, Aberford, near Leeds.
Jackson, W. G., Whitwood Colliery, Normanton.
Jacques, J. Routledge, Box 21, Heidelberg, Transvaal, S.A.R.
Jameson, Thomas, Wharncliffe Silkstone Colliery, Barnsley.
Jarratt, J., Houghton Main Colliery, Barnsley.
Jeffcock, C. E., Birley Colliery, Sheffield.
Jeffcock, T. W., 18, Bank Street, Sheffield.
Jeffery, G. F., 44, Park Square, Leeds.
Jenkins, W., Ocean Collieries, Treorky, Glamorgan.
Jenkins, Wm., Consett Iron Works, Consett, Durham.
Jepson, H., 20, The Avenue, Durham.
Jeudwine, W. W., Abercrombie Street, Chesterfield.
Jobling, T. E., Croft Villa, Blyth, Northumberland.
Johnson, F. D., Aykleyheads, Durham.
Johnson, H., Jun., Mining Offices, Trindle Road, Dudley, South Staffordshire
Johnson, J., Carlton Main Colliery, Barnsley.
*Johnson, R. S., Sherburn Hall, Durham.
Johnson, W., Abram Colliery, Wigan.
Johnson, Wm., Radcliffe Colliery, Acklington, Northumberland.
Joicey, J. G., Forth Banks West Factory, Newcastle-on-Tyne.
Joicey, W. J., Sunningdale Park, Berkshire.
Jones, E., 12, Gateford Road, Worksop.
Jones, F. J., Rother Vale Colliery, Treeton, near Rotherham.
Jones, John, Shire Oaks Colliery, Worksop.

Kayll, A. C., Gosforth, Newcastle-on-Tyne.
Keep, J. S., 11, Broad Street, Birmingham.
Kell, G. J., Beech Grove, Locke Park, Barnsley.
Kellett, William, Portland Bank, Southport.
Kendall, John D., Roper Street, Whitehaven.
Kenrick, John P., 37, Westwood Street, Moss Side, Manchester.
Kesteven, Frank, Monckton Main Colliery, Barnsley.
Ketley, J. H., Glynthurst, Yardley, near Birmingham.
Kirkby, J. W., Kirkland, Leven, Fife.
Kirkhouse, E. G., 1, Edith Street, Consett, Co. Durham.
Kirkup, Philip, Cornsay Colliery Office, Esh, near Durham.
Kirton, Hugh, Waldridge Colliery, Chester-le-Street.
Knighton, H. A., Bagworth, Leicester.
*Knowles, A., Swinton Old Hall, Manchester.
Knowles, I., Wigan.
Knowles, John, Westwood, Pendlebury, Manchester.
Knowles, Robert, Ednaston Lodge, near Derby.
Knox, James, Haunchwood Brick and Tile Company's Works, Nuneaton.

Lamb, George, Butterley Park Collieries, Alfreton.
Lamb, R., Bowthorn Colliery, Cleator Moor, near Whitehaven.
Lamb, R. O., The Lawn, Ryton-on-Tyne.
Lamb, Richard W., 29, Great Cumberland Place, London, W.
*Lampen, G. J., Kirkgate, Wakefield.

LANCASTER, JOHN, Anfield House, Leamington.
LANCASTER, JOHN, Auchinheath, Southfield and Fence Collieries, Lesmahagow.
LANDALE, A., Comely Park Place, Dunfermline.
LAPORTE, H., Flénu, near Mons, Belgium.
LAVERICK, J. H. W., Riddings Colliery, near Alfreton.
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LAWRENCE, H., Grange Iron Works, Durham.
*LAWS, H., Grainger Street West, Newcastle-on-Tyne.
LAWS, W. G., Town Hall, Newcastle-on-Tyne.
LAWTON, WM., 98, Kirkmanshulme Lane, Longsight, Manchester.
LEA, H., 38, Bennett's Hill, Birmingham.
LEACH, C. C., Seghill Colliery, Northumberland.
LEAVER, J. R., 13, Brookfield Terrace, Swansea.
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LIDDELL, J. M., 3, Victoria Villas, Newcastle-on-Tyne.
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LISHMAN, WM., Bunker Hill, Fence Houses.
LISHMAN, WM., Holly House, Witton-le-Wear.
LISLE, J., De Beers Mine, Kimberley, South Africa.
LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London, W.
LIVERSEDGE, W. G., Norfolk Road, Sheffield.
LIVESEY, C., Bradford Colliery, near Manchester.
LIVESEY, T., Bradford Colliery, near Manchester.
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LLEWELYN, L., Abersychan House, Abersychan.
LOGAN, WILLIAM, Langley Park Colliery, Durham.
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LOWDEN, T., Hamsteels, near Durham.
*LOWRANCE, J., Peel Square, Barnsley.
LUCAS, SAMUEL, Dronfield Foundry, Dronfield, Sheffield.
LUPTON, Prof. A., 6, De Grey Road, Leeds.
LYON, J., Walsall Wood, Walsall.

MacCabe, H. O., Russell Vale, Wollongong, New South Wales.
Mackinlay, T. B.
Maddison, Thos. R., Dirtcar House, near Wakefield.
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May, G., Harton Colliery Offices, near South Shields.
May, T. H., Times Buildings, Bow Street, Sheffield.
McAdoo, John.
McCarthy, E. T., c/o Col. Pigott, Archer Lodge, Charles Road, St. Leonards-on-Sea, Sussex.
McCreath, J., 95, Bath Street, Glasgow.
McCulloch, David, Beech Grove, Kilmarnock, N.B.
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McMurtrie, G. E. J., Foxes Bridge Colliery, Cinderford, Gloucestershire.
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Merivale, Prof. J. H., M.A., 2, Victoria Villas, Newcastle-on-Tyne.
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Middleton, Francis Ed., Lofthouse, near Wakefield.
Miles, Wm. Hy., Town Engineer, Johnannesburg, Transvaal, South Africa.
Miller, D. S., Cheadle, Staffordshire.
Miller, N., 31, Hyde Lane, Hyde, near Manchester.
*Miller, R., Beech Grove, Locke Park, Barnsley.
Mills, M. H., 65, Station Street, Nottingham.

MILNE, Prof. JOHN, University of Tokio, Japan.
MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne.
MITCHELL, JOSEPH, Mining Offices, Barnsley.
MITCHELL, T. W. H., Mining Offices, Barnsley.
MITCHINSON, R., Jun., Pontop Colliery, Lintz Green Station, Co. Durham.
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NEVIN, JOHN, Littlemoor House, Mirfield.
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NEWILL, C. E.
NICHOL, WM., De Beers Mine, Kimberley, South Africa.
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OGDEN, J. M., Solicitor, Sunniside, Sunderland.
OGILVIE, A. GRAEME, 8, Grove End Road, St. John's Wood, London.
OLIVER, C. J., Spring Vale, Spital, Chesterfield.
ORNSBY, R. E., Seaton Delaval Colliery, Newcastle-on-Tyne.
OTTEWELL, DRAPER, 83, Siddal's Road, Derby.
OVEREND, JAMES, Green End, Hawkshead, Ambleside.

PALMER, Sir CHAS. MARK, Bart., M.P., Quay, Newcastle-on-Tyne.
PALMER, A. S., Usworth Hall, Washington Station, Co. Durham.
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PAMELY, C., 21, Morgan Street, Pontypridd, South Wales.
PANTON, F. S., Silksworth Colliery, Sunderland.
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PARSONS, Hon. CHARLES ALGERNON, Elvaston Hall, Ryton-on-Tyne.
PASFIELD, T., Wellington Road, Dudley.
PATTERSON, THOMAS, Craghead, Chester-le-Street.
PATTISON, WM., Morley Main Colliery, Morley, near Leeds.
PAYTON, EDMUND, Yew Tree House, Morleston Street, Derby.
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PEARCE, F. H., Bowling Iron Works, Bradford.
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PICKUP, P. W., 71, Preston New Road, Blackburn.
PIGGFORD, JONATHAN, Sheepbridge Offices, Sheepbridge, Chesterfield.
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POLLARD, JOHN, Central Chambers, King Street Wakefield.
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REYNOLDS, JOHN JAMES, 86, Harroll Terrace, Swinton, Manchester.
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ROTHWELL, R. P., 27, Park Place, New York, U.S.
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Schram, **Richard**, 17a, Great George Street, Westminster, London, S.W.
Scott, **Andrew**, Broomhill Colliery, Acklington.
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Shone, **Isaac**, Great George Street Chambers, Parliament Square, London, S.W.
Shore, **Thomas**, Ireland Colliery, Staveley, Chesterfield.
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SKINNER, SAMUEL, Throapham Manor, Rotherham.
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SNOW, CHARLES, Glapewell Colliery, near Chesterfield.
*SNOWBALL, JOSEPH Seaton Burn House, Dudley, Northumberland.
SNELL, ALBION T., 19, Malden Crescent, Prince of Wales Road, London, N.W.
SOAR, CHARLES, Granville Colliery, Swadlincote, Burton-on-Trent.
SOAR, EDWARD, Kiveton Park Collieries, Sheffield.
SOPWITH, ARTHUR, Cannock Chase Collieries, near Walsall.
SOPWITH, THOS., 6, Great George Street, Westminster, London, S.W.
SOUTH HETTON and MURTON COLLIERIES, OWNERS OF, 50, John Street, Sunderland.
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STEPHENSON, G. R., 9, Victoria Chambers, Westminster, London, S.W.
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STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire.
STRACHAN, ALEXANDER, 131, Station Street, Burton-on-Trent.
STRAKER, J. H., Stagshaw House, Corbridge-on-Tyne.
STRATTON, T. H. M., Cramlington House, Northumberland.
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SUTCLIFFE, A. T., Manor Terrace, Eckington, Rotherham.
SUTTON, WILLIAM, Hemsworth, Wakefield.
SWALLOW, J., Bushblades House, Lintz Green, Newcastle-on-Tyne.
SWALLOW, J. F., Mosboro' Hill House, Eckington, Rotherham.
SWALLOW, R. T., Wardley Hall, Newcastle-on-Tyne.
SWAN, H. F., Beaufront Castle, Hexham.
SWAN, J. G., Upsall Hall, near Middlesbrough.
SWANN, C. G., Secretary, General Mining Association, Limited, Blomfield House, London Wall, and New Broad Street, London, E.C.
SWANN, FRANK, Linby, Nottingham.
SYKES, FRANK K., Springwell Villa, Bishop Auckland.

TANSLEY, A. E., Hawkesbury Colliery, Bedworth, Nuneaton.
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TAYLOR, JOHN HY., Borough Surveyor, Barnsley.
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TOMLIN, JOHN, Granville Colliery, Burton-on-Trent.
TOMLINSON, JOHN, Pilsley Colliery, Clay Cross, Chesterfield.
TOPLEY, WM., of H.M. Geological Survey, 28, Jermyn Street, London, S.W.
TREGLOWN, C. H., Wretham Road, Handsworth, Birmingham.
TURBUTT, W. G., Ogston Hall, Alfreton.
TURNBULL, ROBERT, South Kirkby Colliery, Wakefield.
TURNER, G. R., Langley Mill, Nottingham.
TURNER, JOHN, Coleorton Colliery, near Ashby-de-la-Zouch.
TYAS, A., Warren House, Sheffield Road, Barnsley.

Tyers, John E., Nerbudda Coal and Iron Company, Limited, Mohpani Coal Mines, *via* Gadawarra, C. Provinces, India.
Tyzack, D., 71, Westgate Road, Newcastle-on-Tyne.
*Tyzack, Wilfred, South Medomsley Colliery, Lintz Green, Newcastle-on-Tyne.

Varley, John, Park View, Hill Top, Eastwood, Notts.
Varty, Thomas, Skelton Park Mines, Skelton, R.S.O., Cleveland.
Vasey, T. W., 123, Tynemouth Road, Heaton.
Victoria Garesfield Colliery, Owners of, c/o George Peile, Esq., Shotley Bridge, Co. Durham.
Vitanoff, Geo. N., Sofia, Bulgaria.
Vivian, John, Diamond Boring Company, Whitehaven.

Wadham, E., Millwood, Dalton-in-Furness.
Wain, Wm. Holt, Podmore Hall Colliery, Newcastle-under-Lyne.
Walker, G. Blake, Wharncliffe Silkstone Colliery, Barnsley.
Walker, Hy. S., Netherthorpe, Worksop.
Walker, J. S., Pagefield Iron Works, Wigan, Lancashire.
Walker, Sydney Ferris, 196, Severn Road, Canton, Cardiff.
Walker, W., Hawthorns, Saltburn-by-the-Sea.
Walker, Wm., Jun., H.M. Inspector of Mines, Durham.
Walker, William Edward, Lowther Street, Whitehaven.
Wallace, Henry, Trench Hall, Gateshead.
Wallace, J., King Street, Wigan.
Wallau, Jacob, Messrs. Black, Hawthorn, and Co., Gateshead.
Walters, Hargrave, Birley Collieries, near Sheffield.
Walters, J. T., Hill Crest, High Street, Old Basford, Nottingham.
Walters, R. G., Shirtcliff House, Woodhouse, Sheffield.
Walton, J. Coulthard, Writhlington Colliery, Radstock, *via* Bath.
Walton, M., Dearham Colliery, Carlisle.
Walton, W. W., Croft Cottage, Ferryside, near Carmarthen, South Wales.
Warburton, J. S., 49, New Road, Greys, Essex.
Ward, H., Rodbaston Hall, near Penkridge, Stafford.
Ward, T. H., Ainlea House, Alexandra Road, Crosby, near Liverpool.
Ward, W., Churwell Colliery, Leeds.
Wardell, S. C., Doe Hill House, Alfreton.
Watkyn-Thomas, W., Mineral Office, Cockermouth Castle.
Washington, W., Mitchell Main Colliery, Barnsley.
*Watson, A., New Seaham Colliery, Sunderland.
Watson, Simeon, New Hucknall Colliery, Mansfield.
Waugh, C. L., Ffalda Steam Coal Colliery, Garw Valley, near Bridgend.
Wearmouth Colliery, Owners of, Sunderland.
Wears, W. G.
Webster, H. Ingham, Morton House, Fence Houses.
Weeks, J. G., Bedlington, R.S.O., Northumberland.
Weeks, R. L., Willington, Co. Durham.
Weightman, Percy O., Sheffield Road, Woodhouse, near Sheffield.
Wells, W. E., Eckington Collieries, Rotherham.
Westmacott, P. G. B., Elswick Iron Works, Newcastle.
White, C. E., Hebburn Colliery, near Newcastle-on-Tyne.
White, H., Walker Colliery, Newcastle-on-Tyne.
White, J. F., Westgate, Wakefield.
White, J. H. R., The Elms, Thringstone, Coalville, Leicester.

White, I. W. H., Woodlesford, near Leeds.
Whitehead, James, Brindle Lodge, near Preston, Lancashire.
Whitehouse, W. H., Brownhills, Walsall.
Whitelaw, John, 118, George Street, Edinburgh.
Whiting, S. B., Philadelphia and Reading Coal and Iron Co., Pottsville, Pennsylvania, U.S.A.
Whittem, Thomas S., Wyken Colliery, Coventry.
Widdas, C., North Bitchburn Colliery, Howden, Darlington.
Wight, Edwd. S., Mount Keiron Colliery, Wollongong, New South Wales.
Wight, W. H., Cowpen Colliery, Blyth.
Wilde, William, Brockett House, Sharrow, Sheffield.
Wilkes, John, Pelsall, near Walsall, Stafford.
Wilkinson, Thomas, Clay Cross, Chesterfield.
Wilkinson, Thomas, Tinsley, near Sheffield.
Williamson, J., Cannock Wood, Hednesford.
Williamson, Thomas, West Hallam Collieries, Ilkeston.
Wilson, A. P., Mansion House Chambers, Queen Victoria Street, London, E.C.
Wilson, J. B., Wingfield Iron Works and Colliery, Alfreton.
Wilson, J. D., Ouston House, Chester-le-Street.
Wilson, Josh. M., St. John's Colliery, Normanton.
Wilson, John Robinson, c/o T. A. Walker, Esq., Contractor, Manchester Ship Canal, Manchester.
Wilson, Robert, Flimby Colliery, Maryport.
Wilson, W. B., Thornley Colliery, by Trimdon Grange, Co. Durham.
Wilson, W. E. C., The Bank, Alfreton.
Winstanley, Robt., 28, Deansgate, Manchester.
Winter, T. B., Grey Street, Newcastle-on-Tyne.
Withers, Samuel, 26, Westgate, Mansfield.
Witty, H. Sykes, Denaby Main Colliery, Mexboro', near Rotherham.
Wood, C. L., Freeland, Forgandenny, Perthshire.
Wood, John, Birch Coppice Colliery, Tamworth.
Wood, John, Coxhoe Hall, Coxhoe, R.S.O., Co. Durham.
Wood, Lindsay, The Hermitage, Chester-le-Street.
Wood, Thomas, Rainton House, Fence Houses.
Wood, T. P., Market Place, Chesterfield.
Wood, W. H., Coxhoe Hall, Coxhoe, Co. Durham.
Wood, W. O., South Hetton, Sunderland.
Woodhead, E., Low Moor Ironworks, Bradford.
Woodhead, L., Beeston Colliery, Leeds.
Woodiwiss, Alfred, Belair, Trafalgar Road, Birkdale, near Southport.
*Woolcock, Henry, St. Bees, Cumberland.
Wootton, John, Coalville, near Leicester.
Wordsworth, Robert, St. John's Colliery, Normanton.
Wormald, C. F., Mayfield Villa, Saltwell, Gateshead-on-Tyne.
Wright, Joseph, Arboretum Street, Nottingham.
Wrightson, T., Stockton-on-Tees.
Wroe, James, Lidgett Colliery, Tankersley, Barnsley.
Wroe, Jonathan, Wharncliffe Silkstone Colliery, Barnsley.
*Wynne, Thomas, H.M. Inspector of Mines, Gnossal, Stafford.

Yeoman, T., Brandon Colliery, near Durham.
Young, John A., 7, Tyne Vale Terrace, Gateshead.

SUBJECTS FOR PAPERS.

The subjects in the following list are suggested as among the most suitable, viz. :—

Boring, sinking, tunnelling, brakes, building construction.

Coal-dust, coal getting, coke manufacture, colliery management, compressed air, concrete, cottages, cranes, hoists, and lifts.

Drainage of lands, drainage of mines, drainage of towns and buildings.

Electricity, applications of, electricity as a motive power, electric communications and signalling, electric lighting, explosions, accounts of, explosive agents.

Filtration, foundations, furnaces.

Gas as a motive power, geological facts.

Haulage, heat, utilisation of, horse and horse-power, hydraulic machinery.

Irrigation, iron manufacture, ironstone mining.

Lead mining, lead ores and manufacture, lead works, description of, limestone quarries and works, lubricating materials and methods.

Machinery of all kinds, mathematical and other instruments, metallurgy, meteorological statistics, minerals of all kinds, minerals, working and raising, mine ventilation, mining in all its branches, mining details, motive power, all kinds of.

New methods, account of, new works, description of.

Paint manufacture, pit shafts, pottery manufacture, pumping machinery.

Quantities and cost of works.

Railways, construction and working, railways, underground, reservoirs, rivers and streams, improvements of, road making, rock drills, rope haulage, rope manufacture.

Safety hooks and cages, safety-lamps, sanitary engineering, screening, sewage disposal, signalling, sinkings and borings, records of, syphons, particulars of working, slag, utilization of, slate quarrying, smoke prevention, steam engines and boilers, steel in constructions, steel manufacture, streets, pavements, roadways, etc., surface plant at mines.

Timber, tools, tramways, transit, tubbing shafts, details of.

Ventilation.

Washing and separating minerals, water and water-works, water power, winding machinery.

All drawings and diagrams illustrating papers should be boldly but clearly drawn, *having the scale delineated*, and not written only, with a view to reduction by photography.

The communications should be written on foolscap paper, on one side only of each page, leaving a clear margin on the left hand side for binding, and they should be written in the third person.

FOREIGN ABSTRACTS.

The Secretary (Mr. Walton Brown, Neville Hall, Newcastle-upon-Tyne) will be pleased to receive communications from members who are willing to assist in the compilation of abstracts of papers upon mining, etc., appearing in foreign transactions, newspapers, etc.

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TRANSACTIONS

OF THE

FEDERATED INSTITUTION OF MINING ENGINEERS.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

NOTES ON THE GEOLOGY OF THE MANCHESTER CANAL.

By C. E. DE RANCE,
Assoc. Inst. C.E., F.G.S., F.R.G.S., Hon. Member Manchester Geol. Soc.

[Read in August, 1889.]

The Manchester Canal, in the course of its progress from Salford to Eastham, traverses the southern margin of the County of Lancashire, and hugs the northern limit of the County of Chester, represented on the one-inch map of the Ordnance Survey, passing from east to west, by quarter sheets, 89 S.E., 80 N.E., 80 N.W., and 79 N.E. The whole of these maps are published both for the "solid" and "superficial deposits." The latter edition, representing the actual surface-deposits, Glacial Drift, Peat, and Alluvium ; the former, the rocks beneath, as if the Drift had been entirely swept off, or rendered transparent.

Much information will be found in the explanations of these quarter sheets, published by the Geological Survey, which—together with the numerous papers of the late Mr. Binney, F.R.S., Prof. Hull, F.R.S., and those of the author, published in the Quarterly Journal of the Geological Society of London, the Transactions of the Geological Society of Manchester, and the Reports of the British Association for the Advancement of Science—form the basis of the following notes.

The Coal-measures do not occur at the surface at any part of the course of the canal ; but there can be no doubt that they underlie the greater part of the new navigation, if not the whole, being at some points within a practical depth, to enable working the coal to take place. How high an importance it will be to have coaling stations alongside the canal in the future is at once obvious.

The Lancashire Coal-measures consist of an Upper, Middle, and Lower series, together reaching a thickness of more than a mile and a half, not including the Millstone Grit beneath. The Upper division reaches the surface, east of the Salford Docks, forming the Manchester Coal-field, occupying an area of four square miles, the section being in descending order as follows :—

	Feet.
Limestone Series	600
To Openshaw Coal	600
From Openshaw to Yard Coal	485

Between these measures, and the Middle Coal-measures of the Wigan Coal-field, are nearly 2,000 feet of reddish sandstone and shales. The weak brine springs and brackish waters met with in numerous borings in the New Red Sandstone are probably derived from this horizon between Manchester and Warrington. At Bradford and Clayton, east of Manchester, the Four-foot Mine occurs 108 feet above the Yard Mine, and may be taken as the equivalent of the Four-foot Mine of Worsley and Pendleton, constituting the base of the Upper Coal-measures. The Limestone Series are more fully developed at Ardwick than in any other part of England, six beds occurring with an aggregate thickness of 15 feet, the lowest and thickest being 6 feet. The limestones contain *Spirorbis Carbonarius* and fish remains, as *Ctenodus*. At Patricroft Colliery, a mile north of the canal, a shaft has been sunk in to the Upper Coal-measures, through the Permian marls and sandstone, which rest unconformably on 10 feet of Coal-measure shale, lying on 2 feet of calcareous hematite, forming a valuable iron ore, containing 22 to 26 per cent. of metal, with 40 per cent of carbonate of lime, the iron varying from a carbonate to a peroxide. It occurs at 44 yards from the surface and 396 yards above the Worsley Four-foot Coal.

At Lymm a deep boring in the Bunter Sandstone yielded a strongly brackish water ; the well and boring discovered in the process of the canal works near Barton is slightly brackish. At Dallam Lane Forge a boring in the same formation resulted in finding a salt water, which steadily increased in saltness until, at a depth of 818 feet, the contained salts were no less than 4,500 grains per gallon. Two miles and a half north of Dallam Forge is the Winwick pumping station of the Warrington Waterworks Company, at which occurs a very important boring, throwing much light on the Palæozoic floor of the Mersey valley around Warrington. The section is as follows :—

	Feet.	Inches.
Drift	30	0
New Red Sandstone	310	6
Upper Coal-measures	33	6
Limestone Series	37	0

It is probable that the Coal-measures underlie Warrington at a depth of 400 yards, at a horizon considerably above the Limestone Series, and should, as is probable from the comparison of their microscopic character, the Winwick and Ardwick Limestones belong to the same horizon, it is probable that the horizon, containing the Openshaw Coal, or its equivalent, may be found under the Latchford portion of the canal, at a depth of not more than 600 yards.

The Permian rocks form a narrow band, fringing the Wigan and Bolton Coal-field. Their nearest approach to the canal is at the Patricroft Colliery, of which the following is a section in descending order :—

	Feet.	Inches.
Drift	15	0
New Red Sandstone...	19	0
Permian Upper Marls and Fossiliferous Limestone, lowest 2 feet thick	71	5
Permian Lower Red Sandstone and Conglomerates	21	0
Upper Coal-measures	1,193	10
Worsley Four-foot Coal	4	0

At Collyhurst, east of Manchester, the Lower Permian Sandstones reach 250 feet in thickness, and are known as the "Collyhurst Sandstones," while still further east, at Clayton Vale, they are no less than 752 feet thick.

The whole of the works of the Manchester Ship Canal, from the Salford Docks to the outlet at Eastham, are carried out in the *New Red Sandstone*, or *Triassic* Series of rocks. These, so far as the British Isles are concerned, attain their maximum thickness in the river basin of the Mersey and the Dee; they consist of the following sub-divisions, in descending order :—

		Thickness in Feet.
KEUPER	Red Marls, with two beds of Rock Salt	1,200
	Waterstones, Shales, and Sandstones	200
	Frodsham Beds, Soft Sandstone	100
	Building Stones and Conglomerate...	300
BUNTER	Upper Mottled Sandstones	400
	Pebble Beds	1,000
	Lower Mottled Sandstone	100

The extensive system of N.N.W. faults which divide up the Lancashire Coal-field into a series of belts, extends southwards into the Triassic area, traversed by the ship canal. No less than four of these faults intervene between Manchester and Warrington, are heavy downthrows to the east, and as the dip of the rocks is steadily southwards, they have the effect of repeating the beds, and counteracting the effect of the dip.

Examining the Triassic rocks of Lancashire in detail, in ascending order, the Lower Mottled Sandstone is found to be composed of well-rounded grains, resembling those of modern blown sands, and contains no trace of life. It is of interest to note that the modern sand-dunes of the Lancashire coast, which often reach a height of 80 feet, seldom contain pebbles, that the passage of rain water through them, charged with carbonic acid gas, derived from the atmosphere, dissolves out shells of mollusca, blown up with the sands, which are very extensively current-bedded, the varying intensity and change of direction in the wind-currents at the time of their deposition being clearly impressed. Similar sweeping planes of current-bedding are noticeable in the Lower Mottled Sandstone, at the Eastham end of the Manchester Canal; and there is strong probability that it was originally a blown sand.

In the Pebble Beds above, the shingle beach character to which they owe their name in the Cannock Chase country is absent in Lancashire and Cheshire, and the conditions appear to have alternated between sandy shore lines with some pebbles, pointing to movements of water, causing denudation, and the arrest in velocity of these currents, and the deposition of the coarser sands carried by them. Inconstant shale beds point to occasional tranquil deposition, which the presence of pseudo-morphous crystals of salt, ripple-marks, sun-cracks, and rain-drops prove took place in isolated lagoons.

Beds of fine grained sands, intercalated with the above deposits, testify in their loosely aggregated well-rounded grains* to conditions similar to those obtaining in the preceding Lower Mottled Sandstone, which I attribute to an ancient blown sand.

The Upper Mottled Sandstone, or Upper Bunter, like the Pebble Beds, does not contain any trace of life. Hard bands of angular sand particles occasionally occur, and still more rarely, small pebbles and thin bands of shale, current-bedding is excessive, of a type similar to the Lower Mottled Sandstone below and the Frodsham Sandstones of the Keuper above. It is worthy of note that all three members of the Bunter rapidly thin, or wedge out, in passing to the Midland counties, disappearing along a line drawn south-west from Nottingham to Worcester.

The Keuper Sandstone in Lancashire and Cheshire consists of three members, in descending order, thus:—

Waterstones.
Frodsham Beds.
Building Stones.

* To which I have given the name of "millet seed grain," from their running freely through the fingers like that substance.

The Lower Keuper building stones have an angular grain, and contain pebbles of white vein-quartz, unlike those of the Pebble Beds, which generally consist of dark liver-coloured quartzites or slaty rocks, in the South Lancashire district, at Liverpool, and Ormskirk; they are exceedingly hard and compact, current-bedded, apparently, in water, and are succeeded by soft millet seed grained sandstones, known as the Frodsham Beds, which are doubtless ancient blown sands; up to this horizon the whole of the Permian and Triassic Sandstones lying above the Coal-measures are extensively current-bedded, in two types, one of which is probably the result of change of motion of air, the other of movements of water.

In the Waterstones of the Keuper this feature stops for good, and the beds of fine grained sandstones, with beds of intervening marls, are seen to follow each other with planes of parallel bedding. At Warburton, in the canal cutting, these beds are the sandy base of the overlying Keuper Red or Saliferous marl, which would have continued to be exposed west of Warburton had not the beds been cut off on their dip by a large fault.

The Keuper marls at Bollington, about two and a half miles south-east of Warburton, contain brine springs that were formerly worked for salt, while Northwich, one of the chief Cheshire centres of the salt trade, is only nine miles to the south-south-west.

The section at the oldest mine, that of Marston Old Hall, is as follows:—

	Feet.
Drift Keuper Marl }	144
Top Salt Rock	84
Indurated Marl	30
Second or Bottom Rock	96

The upper bed was discovered in 1680 in boring for coal. It was extensively mined at the end of the last and first half of the present century, but the pillars were left too small, the roof cracked, and the water getting in, the rock salt dissolved, and the greater number of the old mines are now submerged under an extension of the river Weaver, called the Witton Flashes.

The bottom mine was discovered in 1781, and the lower portion of the salt is still worked at the Adelaide mine; but the bulk of the two million tons of salt raised in Cheshire is the result of boiling brine, the different degrees of fineness varying with the amount of heat applied.

The Waterstones contain footprints of *Cheirotherium* and other reptiles, and plant remains like the modern *equisetum* or horsetail, sun-cracks, rain drops, and other evidence of shallow water conditions. Tracing

the Waterstones southwards, they pass insensibly upwards into the overlying Keuper marls in Staffordshire, Leicestershire, and Warwickshire, except around the Charnwood Forest area, where the red marls overlap the Waterstones, and rest directly upon the Palæozoics. This is also the case in the Bristol Channel, both in Somersetshire, Gloucestershire, and South Wales, the Waterstones coming in for the first time to the north-east of the Forest of Dean, east of Mitcheldean and Newent. The Waterstones extend further south than the Bunter, being present in the Burford boring in Oxfordshire, where they rest directly on the Coal-measures. The coarse Lower Keuper Sandstone, or building stone of the north, is represented by a few feet of hard strata at Nottingham, and a few inches at Nuneaton, where the overlying Waterstone and Sandstone forms a very fair building stone, representing a mingling of the conditions of the north and the Midland areas.

The Ship Canal works canalize the river Irwell from Salford to Irlam, where it falls into the Mersey; then it canalizes the latter stream to Warrington. The Irwell is 22 miles in length, but with bends it extends 50 miles, and drains an area of 312 square miles, made up as follows :—

	Square Miles.
Triassic Rocks	28¾
Permian Rocks	10
Carboniferous Rocks	273¼

The greater part of the area above Salford is of an impermeable character, and the inclination of the river bed being only 4 feet to the mile, heavy floods are the result. The mean annual rainfall in Salford is 35 inches, and is much higher in the upper reaches of the basin, which rise to 1,000 feet above Ordnance datum.

The Irwell at Salford flows through what has been called by Professor Green, a "valley within valley," the rock surface being filled in with thick deposits of glacial drift, consisting of beds of boulder clay, divided by an intervening bed of sand and gravel. These deposits have been worn into a deep and wide valley, with an an alluvial flat at the bottom, resting on an eroded river-worn floor of rock.

Tracing the course of the canal in detail westwards, it is seen to commence immediately west of the "Irwell valley fault," a dislocation of no less than 1,050 yards, in a portion of its course, where it throws the Worsley Four-foot Coal against the Arley mine, respectively the highest and lowest thick coals of the Lancashire Coal-field.

From Salford Dock to Eccles, the canal traverses the Upper Mottled Sandstone until it is cut off by the Worsley fault, a downthrow of 150 yards to the east.

In the Monton Drainage Works the Worsley fault was well seen in 1880, the upper part of the Pebble Bed of the New Red Sandstone being thrown against the Coal-measures, at an horizon probably about 300 yards above the Worsley Four-foot Coal, overlaid by Permian Sandstones. The fissure of the fault was filled with two materials—first, Boulder Clay, with glaciated erratic fragments from the Lake District, then a belt of bleached white sandstone. The fault acted as a puddled barrier, the workings on the Coal-measure side being dry and dusty, and a large quantity of water being met with on cutting through it. The direction of the fault could be distinctly traced across the grass of the adjacent park upon the early dewy mornings.

A mile further south, where the fault is traversed by the canal, the evidence of its position is not so marked, from the similarity of the grain of the Upper Mottled Sandstone, and the underlying Pebble Beds, the scarcity of pebbles in this district in the latter formation, and the numerous joints traversing these sandstones, ranging parallel to the main faults.

The action of faults, in wholly porous rocks, like the New Red Sandstone, does not arrest the passage of water, the fissures being filled with porous material. The four wells of the Liverpool Corporation Water Supply, which now together yield about six million gallons of water, though separated by faults of great magnitude, are found to increase their supply when pumping ceases at one of their number. In the neighbourhood of Eccles, the Upper Mottled and Pebble Beds beneath have been bored into at the London and North-Western Railway Station, and a good supply of water obtained east of the fault, while immediately west of it a recent boring at Messrs. Holdsworth & Gibbs' factory only penetrated the base of the Pebble Beds, and traversed the Upper Coal-measures, with a thin coal seam lying above the Worsley Four-foot Coal. East of Barton a boring on the east side of the Bridgewater Canal, between the Patricroft high road and the canal, obtained a good supply of water out of a bore-hole 400 feet in depth in the New Red Sandstone. Were a boring to be put down at the Barton Aqueduct, it would, doubtless, obtain a good supply of water, and, if carried to sufficient depth, would intersect the Worsley Four-foot Coal.

The excavations of the Manchester Ship Canal, between Salford and Warrington, in the main following the bends of the river, or rather cutting across them, have only disclosed the late post-glacial gravels, resting occasionally on peat beds, with deposits of leaves, nuts, twigs, and stranded trunks of trees. At the Stretford Dock the steam navvy has cut down

into the glacial Boulder Clay, containing numerous examples of glaciated erratic boulders, a large collection of which may be seen opposite the offices of Mr. Bourke, the resident engineer, near Barton. The larger number there collected are of local origin. Numerous examples of the volcanic rocks of the Lake District occur—granites from Cumberland and Criffel, and hematite and iron ore from the Furness district.

The excavations at Barton show a scarp of sandstone 40 feet in height, and old river gravels and overlying silts deposited when the river occupied a different channel. Westward of the Barton Aqueduct the rock and overlying glacial drift slopes westward and disappears, and river gravels form the bed of the canal. They are associated with current-bedded silt, and a profusion of tree trunks. In these deposits at Sticking's Island occurred the *canoe*, now safely housed at the Owens College. The canoe is hewn out of a single trunk, and much variety of opinion exists as to its antiquity, varying from Roman times up to those of only 200 years ago. Similar variety of opinion exists as to the date of origin of a *wooden comb*, found west of the latter find. Later finds in the same leafy silt strongly resemble leather boot laces, and it is probable that these river deposits are very recent, and are due to the swinging to and fro of the river channel across its alluvial flat. Near this point occurs the well, and boring 260 feet in depth, yielding 5,000 gallons per hour of brackish water.

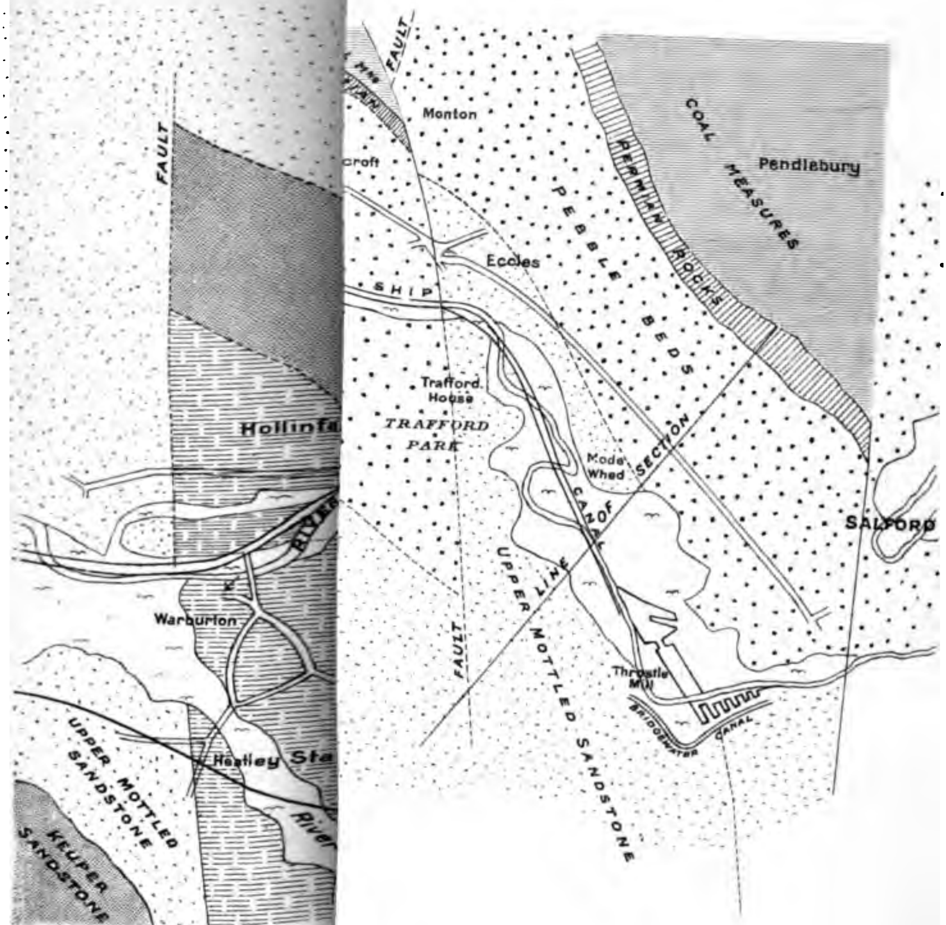
From Stickinedge to Partington the canal passes through the alluvium of the Irwell, and then through that of the Mersey, overlying the soft Upper Mottled Sandstones. At Partington the Lower Keuper Sandstone is seen, containing a few pebbles, which become scarcer in the higher beds, until these beds are overlaid by the Waterstones, extending from Hollinfare to Warburton, where they are cut off by a great downthrow fault to the east of 120 yards.

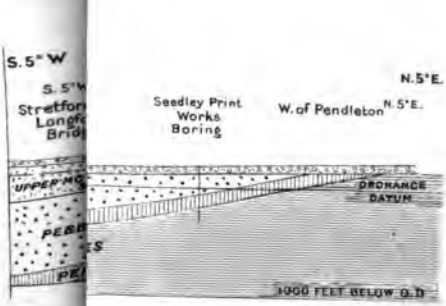
Westward to Latchford the canal follows the alluvium of the Mersey, and overlies the Upper Mottled Sandstone. Between Thelwall and Latchford interesting sections occur of the soft yellow sandstone, overlaid by purple Boulder Clay and capped by later sands.

Nowhere in the canal excavations are any traces visible of true glaciation of the rock surface, though river-worn action is recognisable.

r Canal."

Adapted from
Geological S
of one inch





PROCEEDINGS.

FEDERATED INSTITUTION OF MINING ENGINEERS.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, OCTOBER 12TH, 1889.

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, which were confirmed.

The SECRETARY reported the proceedings of the Council of this Institute, also of the first meeting of the Council of the New Federated Institution of Mining Engineers, embodying the election of representatives from this district as follows:—Sir Lowthian Bell, Bart.; and Messrs. W. Armstrong, Jun.; M. Walton Brown; W. Cochrane; J. Daglish; T. Douglas; G. B. Forster; G. C. Greenwell; J. Marley; G. May; J. B. Simpson; A. L. Steavenson; J. Willis; and L. Wood.

Among the members co-optated by the new Council were Messrs. W. Armstrong, Sen.; T. J. Bewick; R. F. Boyd; and D. Dale.

Mr. COCHRANE asked the meaning of the word "co-optate," and whether the "co-optated" members had a seat at the Council? He confessed his ignorance as to the precise meaning of the term.

The PRESIDENT—One of our Past-Presidents has asked the same question. Perhaps the Secretary will explain.

Professor LEBOUR said he learned from Webster's dictionary that to "co-optate" meant to choose together, and when a committee had power to add to its members, then they "co-optated" or "together chose" such other members as they agreed to have on the committee. "Co-optated" members of any council were those not elected by the general body of constitutents, but appointed by the council themselves. They "together chose."

Mr. COCHRANE—Do they always sit?

Professor LEBOUR—Yes.

Mr. COCHRANE—They may do so by right?

The PRESIDENT—Yes.

Professor LEBOUR—They become part of the whole body.

Mr. COCHRANE—I presume "elected by the council" would have a similar meaning?

Professor LEBOUR—Precisely.

The PRESIDENT—The Secretary having been referred to Webster's dictionary by one of the Past-Presidents is able to answer the question.

The following gentlemen were elected, having been previously nominated :—

ORDINARY MEMBER—

Mr. Thomas Robert Maddison (Associate Member), Mining Engineer, Wakefield.

ASSOCIATE MEMBERS—

Mr. Frederick Gosman, Mining Institute, Newcastle-on-Tyne.

Mr. John Hodgson, Mining Engineer, Edmondsley Colliery.

Mr. Edward Hopkins, Mining Engineer, Weardale Place, St. John's Chapel.

Mr. R. Norman Redmayne, Chemical Manufacturer, 26, Grey Street, Newcastle-on-Tyne.

Mr. W. Topley, F.R.S., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London, S.W.

STUDENTS—

Mr. Walter Bell, Mining Engineer, 23, Windsor Crescent, Newcastle-on-Tyne.

Mr. Percy Octavius Weightman, Mining Student, Barrow Colliery, Barnsley.

MEMBERS—

Mr. T. Colquhoun, Mining Engineer, West Stanley Colliery.

Captain William Charles Chitty Erskine, Inspector of Mines, Kimberley, South Africa.

Mr. William Tasker Hallimond, Mining Engineer, Manager of Van Ryn Gold Mining Company, Limited, Boksburg, Johannesburg, Transvaal.

Mr. Jethro Longridge, Colliery Manager, Burradon Colliery, Newcastle-on-Tyne.

Mr. Thomas Lowden, Colliery Manager, Hamsteels, near Durham.

ASSOCIATES—

Mr. William Draper, Assistant Under Manager, New Seaham Colliery, Sunderland.

Mr. John William Forster, Assistant (Certificated Manager, under Act), Silksworth Colliery, Sunderland.

Mr. John Charles Hall, Surveyor, Trimdon Grange Colliery, Co. Durham.

Mr. Francis Burdett Johnson, Mechanical Engineer, 1, Charles Street, Marsden Colliery.

Mr. John Riddell, Under Manager, Shilbottle Colliery, Lesbury, R.S.O.

Mr. John Southern, Master Wasteman, Heworth Colliery, Newcastle-on-Tyne.

Mr. Matthew Walton, Assistant Manager, Dearham Colliery.

Mr. SIMON TATE read the following paper:—

WINDING, BANKING OUT, AND SCREENING PLANT AT EAST HETTON COLLIERY.

By S. Tate.

It having been found necessary to fit up the upcast shaft at East Hetton Colliery for drawing coals and to erect new screening plant, the writer attached great importance to the plant being so constructed as to require the least possible amount of adult manual labour in its working. Banking out in particular is costly owing to the heavy character of the work, and none but the strongest men can perform it in the manner usually performed. To diminish the labour cost and to improve the condition of the merchantable coal were the objects which the writer had in view.

The shaft is 10 feet 6 inches in diameter, and 134 fathoms deep, and has been fitted with iron wire rope guides, the only peculiarity of which is the exceptional manner in which the weights are attached at the bottom. Owing to the small size of the shaft it was found inconvenient to have a separate set of "weights" on each rope, and instead of this a "swinging tree" was attached (see Plate I.) to each pair of ropes, and one set of weights was attached to it.

The advantage of this method is apparent as it allows sufficient shaft room in the centre of the shaft for persons to pass. This is especially useful when the weights are hung midway down the shaft, as it is then somewhat awkward to get past them. The only other remark that need be made concerning these guides is their proximity to each other at "meetings," the intermediate distance being only 6 inches. It would have been preferable to have had them 10 or 12 inches apart, but in practice we have had no trouble with them.

At the shaft bottom the hanging on is fitted up on the same principle as is the No. 3 shaft at Seaham Colliery, from which in fact it is copied (see Plate II.) at the hanging on, each cage road is made as near the size of the cage as possible, with a strong wooden frame carrying sliding doors. When the cage enters this is completely filled, and in its descent it strikes a spanner which is connected with a series of levers, etc., which lifts up the sliding doors on each side of the casing and allows a clear road through the cage for changing the tubs, etc. By the use of these sliding doors the disadvantage of having separation doors on the engine planes or shaft sidings is avoided.

At the shaft top a strong circular walling of brick and stone is built up a sufficient height to support the pulleys, guide ropes, etc., and to carry off the smoke and fumes ascending the pit.

The winding engine is an ordinary vertical single cylinder, 40 inches diameter, of the lever type, and was formerly used with flat ropes. The drum, etc., has been altered and round ropes substituted.

Pit Head and Heapstead.

Plate III. shows the pit head, from which it will be seen that the tubs are moved by gravitation and by engine-power.

The whole of the power required for driving the cleaning belts, tub haulage belts, and the jigger screen is obtained from a single cylinder engine, 14 inches diameter and 2 feet stroke, running 90 revolutions per minute, with an average boiler pressure of 35 lbs. per square inch.

When the cage is at rest upon the keps the inclination of the tub way in the cage is 1 in 48, and as soon as they are struck by the empties entering the full tubs leave the cage and run on to the full roads, which here continue at the inclination of 1 in 48.

They then pass singly (or in pairs as arranged at one colliery) into an improved self-righting patent kick-up, working automatically (see Plate IV.), and so constructed as to enable the emptied tub or corve to be propelled through by the next full tub following in to be emptied. The automatic action is obtained by applying to the bottom of the kick-up a vessel containing liquid, so that after the tub is emptied the weight of the liquid causes it to right itself. Attached to the tippler is a self-indicating weighing machine (see Plate V.), and as soon as the tub enters the tippler the weight is registered, and almost simultaneously the tippler turns over, empties the coals from the tub, and returns to its original position. The empty tub is then weighed, and by this means every tub is weighed both full and empty, and only actual coals passed into the screens are paid for. To enable the weighman to ascertain the hewer and putter of each tub of coals the tokens are hung through a hole in the ends of the tub, and as soon as the tub enters the tippler the attendant calls out the number of the token for both hewer and putter.

The empty tub remains in the tippler until the boy allows another full tub to follow in, which propels the empty one through and on to the line at the point A; it then runs round the semi-circular line to the point B, where the rising gradient begins. An endless belt driven by the screen engine and having projections attached is here kept constantly running. The projections catch the tub axles and draw them up the gradient of 1 in 9 to a point C whence the tub runs down an incline of 1 in 15. At this part the tubs pass over an india-rubber greaser, and then reach the point E when the token boy attends to the switches and sends the cage load of four empties into the proper sidings ready for the arrival of the cage at bank. (See Plate III.)

The whole of the banking out is done by four boys paid as follows:—

1 Boy at Cage Snecks	...	1s. 8d. per day.
1 " " Tippler ...	...	2s. 0d. "
1 " Shover in ...	...	1s. 6d. "
1 " Token Boy	...	1s. 0d. "
Total cost	...	6s. 2d. per day.

Under the old method four banksmen were employed and paid by the score (these men being allowed houses and coals), and their average wage (including value of houses and coals) was 5s. 3d. per day, besides which there was a man to take the tubs on to the weigh, and he was paid at the rate of 3s. 10d. per day, making the total cost £1 4s. 10d. per day, being 18s. 8d. per day, or 3½ times nearly more cost than the cost on the new method.

The total amount of cost and saving per ton for one year, gained by the adoption of the new system of banking out, is as follows:—

	Days Worked per Year.	Tons drawn Annually.	No. of Men or Boys.	Wages per Day. £ s. d.	Total Wage Cost per Year. £ s. d.	Cost per Ton. d.
Old System	280	172,000	5	1 4 10	347 13 4	0·48
New System	280	172,000	4	0 6 2	86 6 8	0·12
Saving	...	...	1	0 18 8	261 6 8	0·36

Screening Arrangements.

When the coals leave the tippler they fall down a spout into a jigging screen (see Plate VI.), where they are assorted into three kinds—viz., bests, nuts, and peas and duff. The best coals are carried along a cleaning belt, 56 feet long and 4 feet wide, where they are cleaned by boys placed along each side of it. The nut coals are delivered out at the side of the jigger on to a belt 33½ feet long by 3 feet wide, parallel with the first belt, but at a different angle, and in travelling the stones are picked out, and the coals cleaned are delivered over a set of screen bars or gauzes, by which the trebles and doubles are separated into their respective wagons. The peas and duff coals drop out at the bottom of the jigger on to a smaller belt, 31 feet long by 2½ feet wide, running in a direction contrary to the other belts, and which carries the coal to an ordinary "beeswing" elevator.

The whole of the cleaning of the coals is done by boys with one man as overlooker or "keeker." The coals are now much better cleaned than they used to be, and at a very much less cost. The comparative wage cost per day is shown in the following table :—

Description.	Old Method.			New Method.		
	No.	Rate.		No.	Rate.	
		s. d.	£ s. d.		s. d.	£ s. d.
Underkeeker	1	4 0	0 4 0	1	4 0	0 4 0
Screenmen, including Houses and Coals to same	12	3 3	1 19 0	...	...	...
Attending Wagons	1	2 10	0 2 10	1	1 8	0 1 8
„ Best Spout	...	...	...	1	1 0	0 1 0
„ Nut „	1	2 10	0 2 10	1	1 4	0 1 4
„ „ „	1	2 0	0 2 0	...	...	...
„ Treble „	2	1 6	0 3 0	...	...	...
Apparatus	1	1 6	0 1 6	1	1 2	0 1 2
Small Runner	2	2 11	0 5 10	...	...	...
„	1	1 10	0 1 10	...	...	...
Jigger Trap and Handle ...	...	...	...	1	0 10	0 0 10
Picking out Stones	...	...	...	20	0 10	0 16 8
Total	...	...	3 2 10	...	...	1 6 8

This shows a saving of £1 16s. 2d. per day or £506 6s. 8d. per annum. The total annual saving on banking out and screening is thus £767 13s. 4d. or 1·07d. per ton.

In this comparison allowance ought to be made in favour of the new method, inasmuch as we now pick out the stones from the double and treble nuts, whereas formerly we only picked out a few stones from the trebles, but never attempted to pick any from the double nuts.

The advantages derived from this system of banking out and screening may be summarised as follows :—

(1.) Cheapness of labour cost, consequent on the utilisation of steam, instead of manual power.

(2.) Cheaper class of labour employed.

(3.) Only coals actually delivered on the screens are paid for.

(4.) Coals are better cleaned and with less breakage.

Mr. G. B. FORSTER said there were three kinds of coal referred to in the paper: best, nuts, and peas and duff; did Mr. Tate mean that peas and duff were one kind?

Mr. TATE—There are three kinds of coal: best, treble nuts, and best nuts, then peas and duff.

Mr. FORSTER—There are only three sorts by the one operation.

Mr. TATE—After the nuts are taken out they are screened by another operation.

Mr. FORSTER said it was not an uncommon thing to get three kinds. He had found the revolving screen better for making nuts than the jigging screen.

Mr. TATE said they were under the impression that the revolving screen broke the nuts.

Mr. FORSTER—Perhaps your coal was very soft, and ours very hard. We had to abandon jigging and put up a revolving screen which makes better nuts.

Mr. TATE—We have now no complaints and we used to have a large number.

The PRESIDENT said this might seem a very short paper, and a subject the details of which it was at one time considered unnecessary to give so much attention to, but he was sure that where they could put an increased value of one shilling a ton on some classes of their coal it was a matter of great importance. Mr. Daglish, through whose personal kindness he had an opportunity of visiting one of his screens, was present, and that gentleman might perhaps give them some information or make some remarks on the subject.

Mr. DAGLISH said this was a subject of great importance, as they all recognised, and was becoming so much so that all new plant was arranged upon some system of the kind indicated. The first place he saw it tried was, he thought, at Mr. Walker's ironstone mines; there the tub ran right round and the system was very effective. This system had been put in at Marsden, but was not in full operation yet. In Wales at several collieries they had elevators, not creepers, which ran the tub round. He did not know whether in Mr. Tate's arrangement the bottom of cage lifts.

Mr. TATE—No, it was found inconvenient.

Mr. DAGLISH said with regard to the kick-up he had not seen one of that kind before, but usually the kick-ups revolved entirely; some ingenious arrangements were made to accomplish this. He thought there was an arrangement of the kind at Heworth, Mr. May had also put one at Boldon, and they had another at Marsden, all effective he believed, but all done in different ways. The kick-up was turned over by machinery, either by friction wheels or surging belts, but it was so little that it could be stopped at the right moment for the tub to be taken out and a fresh one put on. There was no doubt Mr. Tate had taken advantage of all that was known on the subject and had succeeded in arranging a very nice plant. With regard to the jiggers, other jiggers separated the coals in the manner described, they took out best, nuts, and peas and duff.

Mr. TATE—Not at the sides, I think.

Mr. DAGLISH—Yes; Marsden was at the side, and cleaned by a belt. He did not know whether Mr. Tate's belt was arranged the same as that he (Mr. Daglish) first saw at Heworth and adopted at Marsden, namely, with a separation in the middle of the belt to put the stones on.

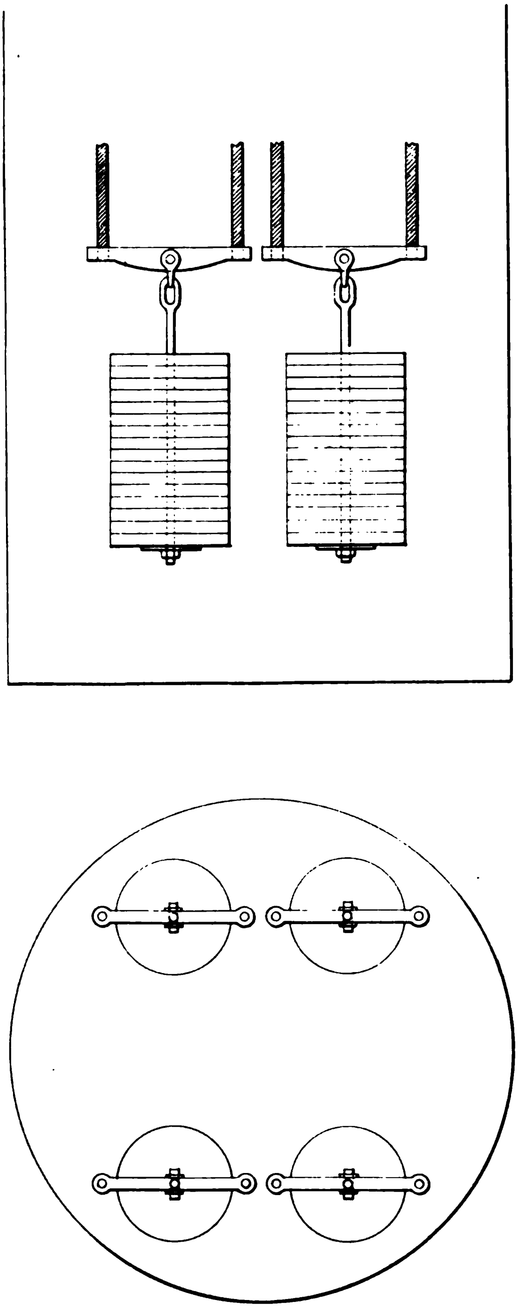
Mr. TATE—Ours has not got that.

Mr. DAGLISH—It is an extremely clever arrangement, and very important; and where they had to take out another kind of coal, as they had to do at Marsden, it would be very troublesome to have to sort them out behind.

The PRESIDENT—Mr. May, I think, is not here to-day, or he would have been able to give us more information.

Mr. FORSTER said he did not quite agree with Mr. Daglish as to the second belt. If they had a second belt on the top for stones——

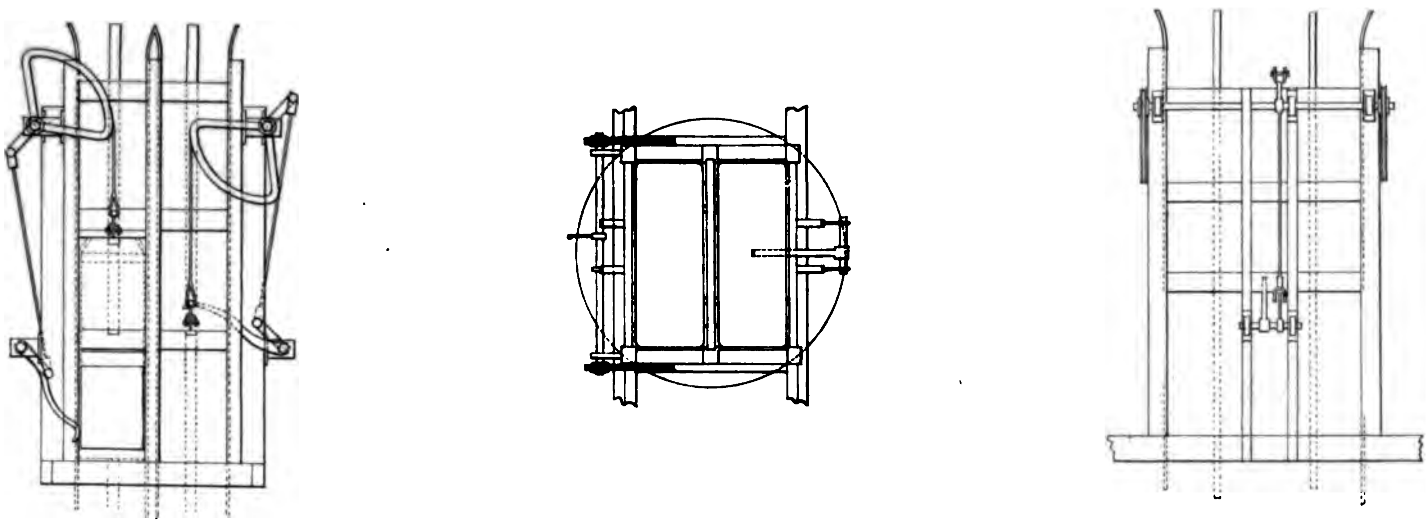
To illustrate Mr S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."



Scale 4 feet to an Inch.

[illegible] Institution of Mining Engineers

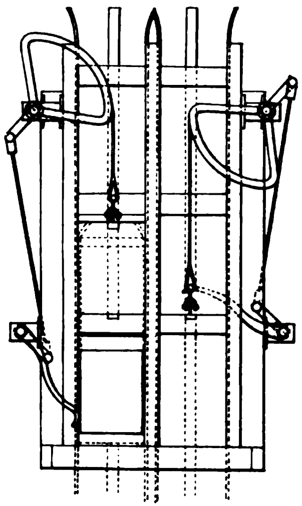
To illustrate Mr. S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."

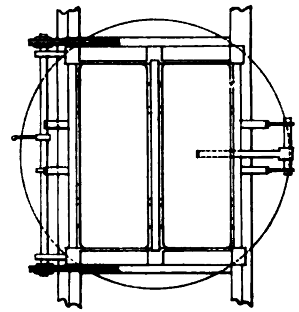


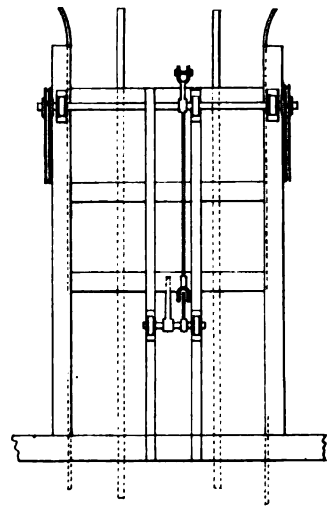
Scale 8 Feet to an Inch

Federated Institution of Mining Engineers
Proceedings 1889-90

To illustrate Mr. S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."





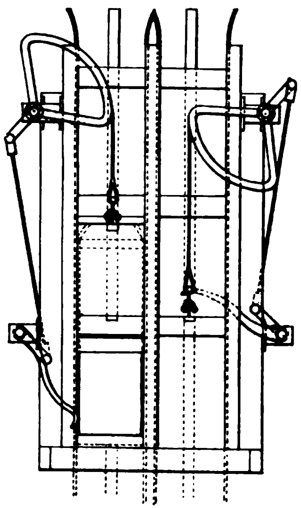


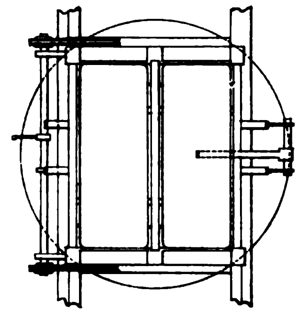
Scale, 8 Feet to an Inch.

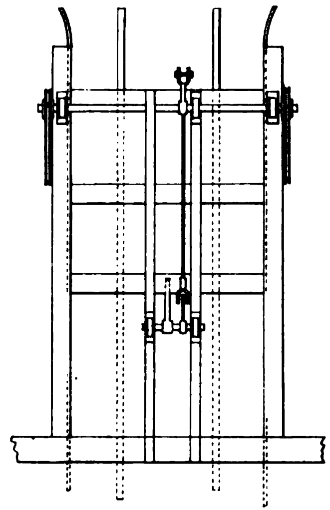
Institution of Mining Engineers
Proceedings 1889-90.

A. Reid, Sons & Co. Lithos. Newcastle

To illustrate Mr. S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."





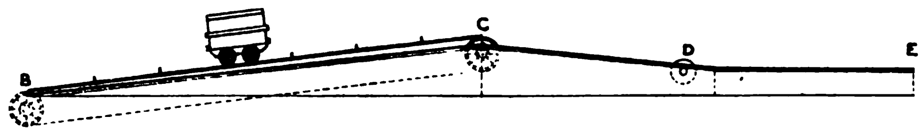


Scale, 8 Feet to an Inch

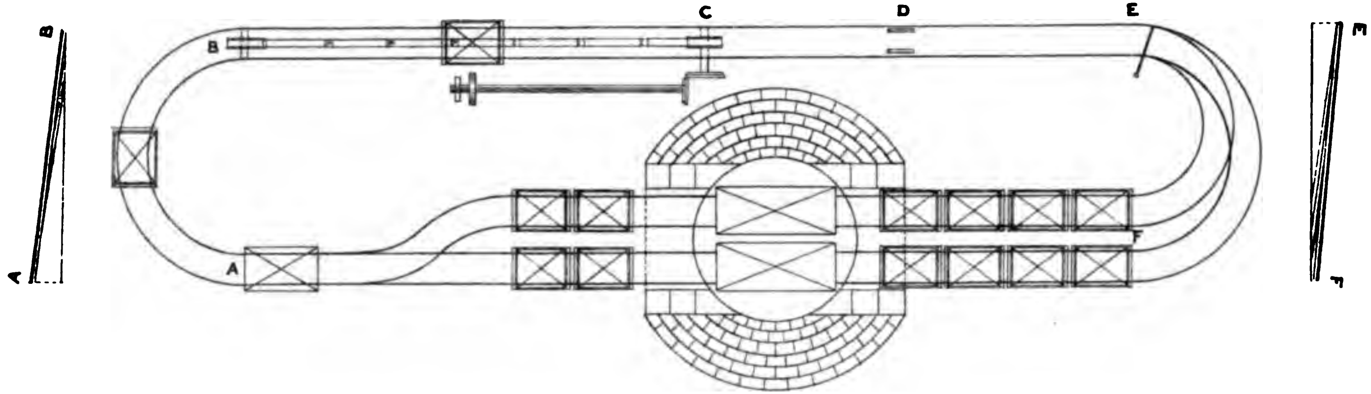
Federated Institution of Mining Engineers
Proceedings 1889-90.

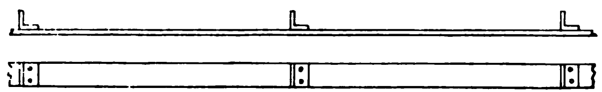
Andw. Reid, Sons & Co. Lithos. Newcastle

To illustrate Mr S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."



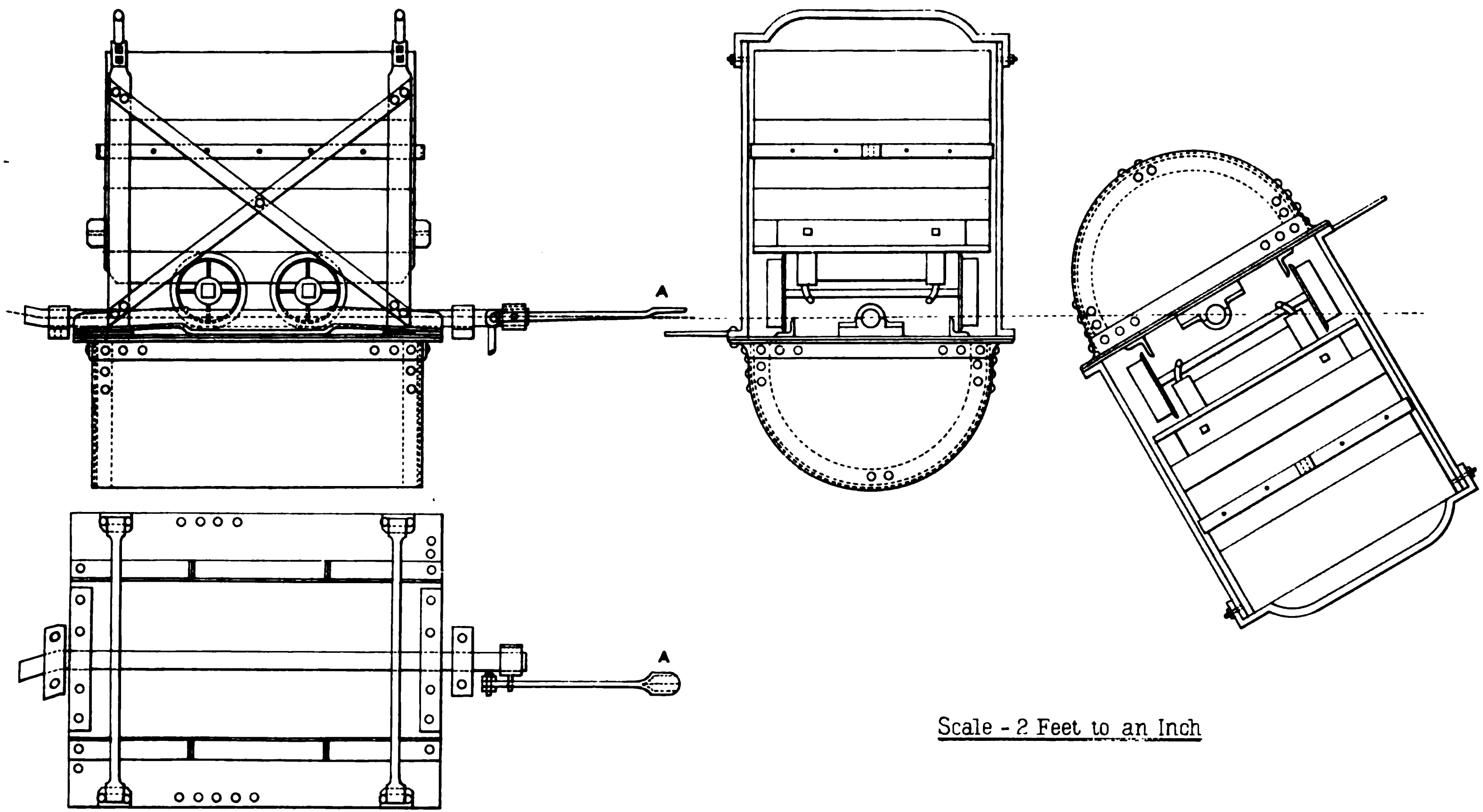
Scale, 12 Feet to an Inch.





Scale 3 Feet to an Inch

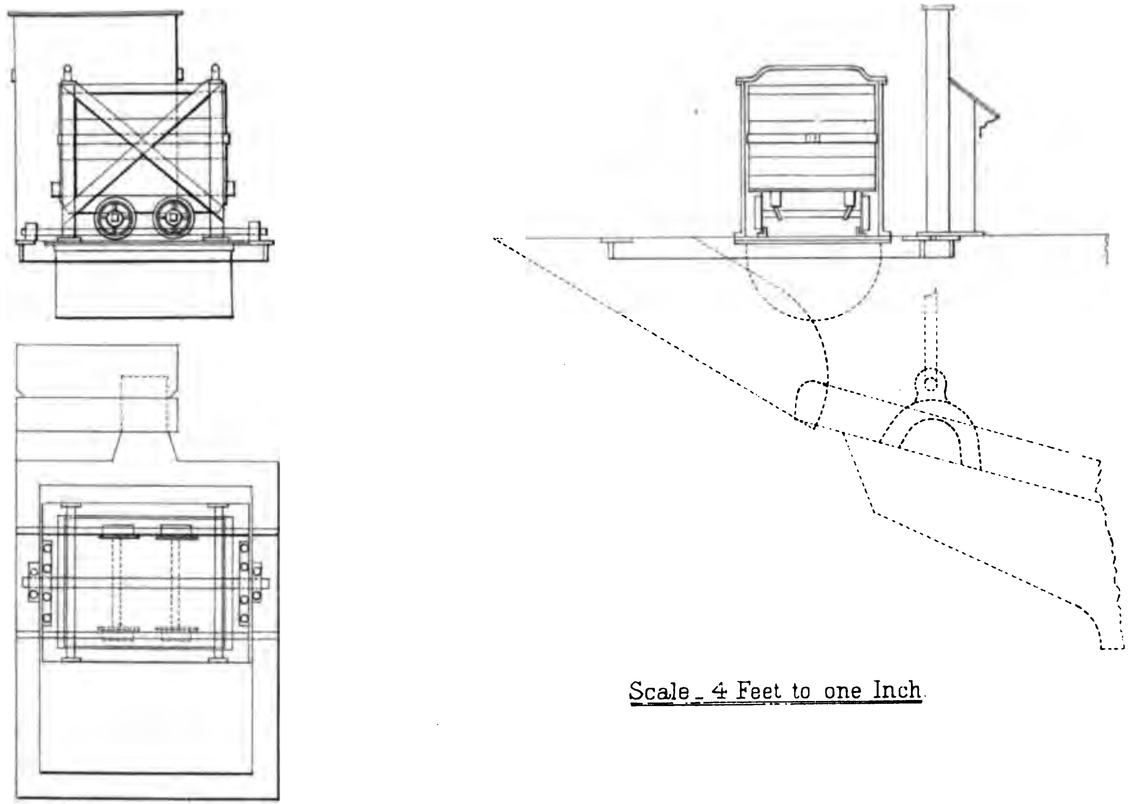
To illustrate Mr. S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."



Scale - 2 Feet to an Inch

Institution of Mining Engineers

To illustrate Mr. S. Tate's Paper "on the Winding, Banking out and Screening Plant at East Hetton Colliery."



Scale _ 4 Feet to one Inch.

Federated Institution of Mining Engineers
Proceedings 1889-90

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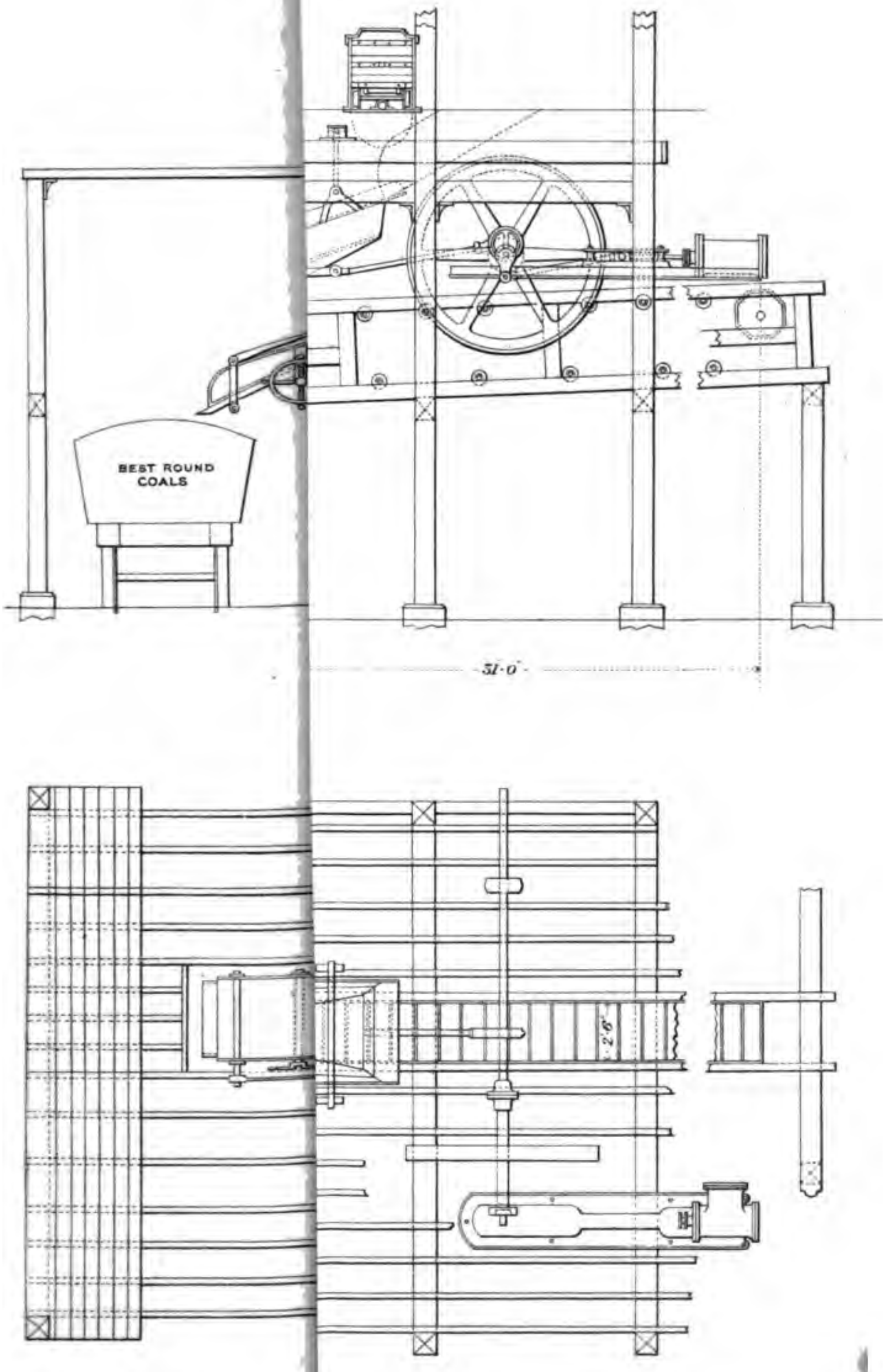
"...ast Hetton Colliery."



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Mr. DAGLISH—It is not a second belt, it is a division.

Mr. FORSTER—It is the same thing. It complicated matters, and added great extra weight to the belt. The way he had done was to put coarse coal on one side and stone on the other, and after work was done run them over the belt.

Mr. TATE said he had considered this point; but in his case it was unnecessary to take them further down than the level of the stone heap.

Mr. THOS. BELL—Mr. Corbett had it at one of his Rainton pits. I think he took it off.

Mr. W. C. BLACKETT said he had had an opportunity of seeing Mr. Tate's arrangement, and could testify to its economy. To him the most striking feature was the kick-up; as regards novelty it was the feature of the whole arrangement. He had seen all the arrangements Mr. Daglish had mentioned, and for simplicity he thought Mr. Tate's beat them all. Nearly all he had seen, if they went right round, had to be assisted by machinery. Mr. Tate's could go right round as easily as part way, and it did so of its own gravitation. As regards the centre belt for stones, in many cases it was not adopted, because boys were paid by the piece. The owners of his colliery decided some time ago to put in belts for the purpose of cleaning unscreened gas coal; this had not been previously done in many cases for unscreened. All their boys were paid by the number of boxes of stone, etc., picked out. One belt they had was 90 feet long and 4 feet wide; another 70 feet long and 5 feet wide; and very great economy had been found in simply cleaning the coal for gas purposes. He believed in the coal going over the belt; they saved nearly a farthing a ton, without considering greater efficiency, and they were picking out almost double the quantity of stones.

Mr. W. J. BIRD said he, like Mr. Blackett, had had the pleasure of seeing Mr. Tate's arrangement, and he agreed that the kick-up was the most striking feature. Another point he was struck with was the belt bringing the empty tub to the requisite height to run by gravitation to the shaft. He had seen arrangements somewhat similar in Wales, where the necessary elevation was obtained by an elevator, a man attending to it; and although there was an attendant available and plenty of power to carry the tubs the necessary distance Mr. Tate's had the advantage: instead of using the whole of his steam power he used only a portion of it, and dispensed with the services of an attendant.

Professor MERIVALE said he was not quite clear as to the kick-up. He gathered that it was not quite automatic; had a boy to start it, or did the weight of the tub set it going? He saw that it came back automatically.

Mr. TATE said it could be hung so as to go itself. As they had it, a boy just gave it a touch, but it would go without.

Professor MERIVALE said he would like to hear an opinion expressed as to the width of the belt. There appeared to be a great difference of opinion on this point. Some approved of 5 feet and upwards; others said that was too much, and made their belts as narrow as 3 feet. In the belts he had put in he had tried to hit the happy medium, and made them 4 feet 6 inches. The wider belts were an advantage if the lads could really reach.

Mr. G. B. FORSTER—I find I must apologise, Mr. Tate. I thought you meant a screen underneath the other jigger.

Mr. TATE—No, sir.

Mr. FORSTER—I was wrong in saying I had used it before.

Mr. DAGLISH—It has two gauzes on the jigger, I suppose?

Mr. TATE—Yes.

Mr. DAGLISH—That is the way we have it at Marsden.

Mr. T. E. FORSTER said in the Midlands they would see as many as four kinds of coal separated. The belts of 40 to 50 feet were generally made in halves—one-half going forward, the other backward, but to the same shaft. He would like to ask one thing about the nuts. Were there many wet coals? In Northumberland they had found the revolving screens the best on account of the wet coals; they could only use the jigging screens for dry coal. As regards the width of the belts, he thought they would find nearly every colliery was in favour of about 4 feet. Some had 5 feet, but if boys were wholly employed that was too wide; 2 feet 6 inches was too far for a boy to reach for stones. With a middle partition a much wider belt was required; in some cases 6 feet. A middle partition was good where one class of coal was picked out, but where there were two or three classes it was rather confusing, as they could only put one kind in the middle. He was not present when the first part of the paper was read, and had not heard what percentage of coal was picked out. As regards paying the boys, he thought it would be best to fix a certain price—say, for picking out stones, and pay them all the same average, for, of course, the boys standing nearest the shoot would have the best chance of picking out most stones, and the lads furthest away the least chance.

Mr. BLACKETT said they found no difficulty in paying every boy for his own work. It would be a mistake to pay a general average, because there was a great difference in boys. Some would earn twice as much as others, not for the reason that one had one end of the belt and the other the other, for they were moved every day. They were never in the same position on the belt two days running.

Mr. TATE said as regards wet coal they had not much. If the coal was very wet it might be difficult; but at Castle Eden they had a jigging screen, and he thought they screened a considerable quantity of wet coal.

Mr. T. E. FORSTER—Making nuts?

Mr. S. TATE—Yes.

Mr. T. E. FORSTER—I thought their screen was a jigging screen.

The PRESIDENT said, although there would be further opportunity for discussion, he thought it was a subject they were all familiar with, and as they were all more or less acquainted with new arrangements he would be glad to hear any further questions or observations.

Mr. THOS. BELL thought it was a mistake to have the belts too wide where they had boys to clean the coal. The boy who had to reach a long way got very tired before night, and would go to sleep half the day if he had the chance. With a 4 feet belt they would get the coal better cleaned than with one 5 feet. He had another reason, too, for saying belts should be narrower. He thought they made a mistake in having boys for this work. If they had women the coal would be better cleaned, and with more peace and satisfaction than with boys. He would advise them to get women to clean the coals; it was a great mistake not to have them.

Professor LEBOUR—At the collieries we visited last month in Belgium nearly all the work of this kind was done by women.

Mr. BELL—Yes; but nearer home than that. Go into Lancashire, Derbyshire, Staffordshire, or North Wales.

The PRESIDENT—The Inspection Act is just passed.

Mr. BELL—Inspection has nothing to do with it.

Mr. BLACKETT apologised for speaking again. He had tried to employ women, and had done everything in his power to do so; he had put out notices asking the men to let their daughters come, and had even offered rewards if one or two would come as a start; but there was a prejudice against it in this county.

The PRESIDENT—Against their acting as screeners, you mean?

Mr. BLACKETT—Quite so; but he did not think they would be able to get them. Even if they could get the women to act as screeners they would have to contend with the union officials.

The PRESIDENT asked if Mr. Logan had anything to say on the subject of the paper?

Mr. LOGAN said he put in two belts lately, and he was of opinion that they could not draw a hard and fast line, and say that 4 feet, 4 feet 3 inches, 4 feet 6 inches, or even 5 feet was the proper width. Every colliery manager knew his own circumstances best, and could best decide on what would suit him both as regards width of the belt, and whether or not he should have a centre compartment. He thought, however, they should not expect a boy to stretch more than about 2 feet 3 inches. He thought cleaning coal from the belt was the most efficient system yet adopted.

The PRESIDENT said, as there were no other remarks offered, it was his pleasing duty to propose a vote of thanks to Mr. Tate. In the first place that gentleman had given him, some time ago, the opportunity of examining the jigger screens and belts, as had also Mr. Daglish and Mr. May. He regretted the last named gentleman was not present to-day, as he would no doubt have been able to give them a good deal of information as to the systems in use at Boldon and St. Hilda. These jigger screens were all the creations or improvements of the last six years; they had been put in in place of old machinery, and they were therefore not all free agents as to the width of belts, etc. When the paper was open again for discussion each member would no doubt be prepared to discuss it in a practical way, and he hoped they would have the pleasure of Mr. May's and Mr. Lawrence's presence, and that they would all hear of something more suitable for their own particular requirements than what they had had hitherto. He had pleasure in moving a vote of thanks to Mr. Tate for bringing this interesting subject forward.

Mr. TATE acknowledged the compliment.

Mr. T. O. Robson's paper on "Faults at Redheugh Colliery," was opened for discussion.

The PRESIDENT—Have you anything new to add, Mr. Robson?

Mr. ROBSON said he had another section (which he proceeded to draw on the blackboard) which went still further to show the inconsistency between the faults described in the previous sections. The one now drawn on the board was proved, since the paper was read, in the Brockwell seam, and represented the same fault at a point 180 yards further west than that shown on the Plate XYZ. Following the seam again for 32 yards they had a dip fault, the extent of which, however, he could not say, as it had not been proved, but from levellings made at both sides, he took it that the dip fault on the one side would be pretty nearly equal to the rise fault on the other. Instead of having a practically level seam at 180 yards further west they had a distinct riser and dipper. It showed that these faults were altogether abnormal and probably, as Professor Lebour had suggested, they were abnormal for the reason that they were a series of conglomerations of faults proved at different depths and showing different characteristics at each point where they were proved. Whether there was any correlation or not he did not know—it was difficult to prove—but he should think not.

Referring to the sketch on the blackboard, the PRESIDENT asked if there was a hading as shown?

Mr. ROBSON said there was little or no hade; the sketch was a very rough one and not quite accurate.

The PRESIDENT—You have no doubt about it being a dipper?

Mr. ROBSON—No sir, not the least; we have the seam on the other side. In printing the Transactions the sections had unfortunately been reversed, the sections on Plate I. should have been on Plate II. and *vice versâ.*

The PRESIDENT suggested that the error might be corrected by an errata slip in the next part.

In the absence of Mr. Pitkin, the Secretary exhibited two of that gentleman's new electric safety-lamps. The older and larger lamp weighed about 8½ lbs. (not quite), cost £2 10s., would burn from 20 to 30 hours, and gave a light of about three candle-power. This lamp, however, the maker had abandoned in favour of the smaller one, weighing 6 lbs. 5½ ozs., costing £2, and giving the same light as the other lamp, for from 10 to 12 hours. It was said there was no danger whatever of breakage, and the lamp could be shaken about a good deal without hurt, but it could not be turned upside down. The principle of the lamp was the secondary battery, the large containing four cells, the smaller one three.

The SECRETARY then read a further communication from Mr. Pitkin and said he had also a note stating that the lamps had been in use at the Waltham gunpowder factory for two and a half years; also at a colliery in Glamorganshire.

Mr. TATE asked if Professor Lebour could say how long it took to recharge the lamps?

Professor LEBOUR—No, I have no further particulars.

Mr. M. WALTON BROWN said there was one point Professor Lebour had not mentioned. There was a resistance coil in the lamp which enabled it to be burned at two different powers. (This was demonstrated with one of the lamps.) With regard to recharging of secondary batteries, in most cases, except where an exciting fluid was used, it took somewhat longer to recharge the lamp than it would afterwards burn. A lamp burning eight hours would probably take ten hours to recharge.

This concluded the business, and the meeting terminated.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

MEETING HELD IN THE UNIVERSITY COLLEGE, NOTTINGHAM, 12TH OCTOBER, 1889.

PRESIDENTIAL ADDRESS.

BY MR. GEORGE LEWIS.

Gentlemen,—I purpose with your indulgence to address you to-day very shortly, it being the first opportunity I have had of doing so since you were good enough to elect me your President for the year. I hope you will allow me to say that I fully appreciate the honour, and also to thank you; but without the assistance and forbearance of each individual member of the Institute I shall be quite unable to render that service the interests of the Institute naturally demand.

I cannot allow the present opportunity to pass without alluding to our late respected President, Lord Edward Cavendish, M.P., who has so ably presided over your meetings since the formation of the Institute in the year 1871. So long a period of service naturally demands from us due acknowledgment, not only from the exalted position held by him, but also for the manner in which he so ably and genially presided over your meetings and in every way furthered the development of the Institute.

We all very much regret that owing to his numerous engagements he was unable to continue holding an office which he hoped he would have filled for some time to come; and it was only when we were compelled to do so that the question of another election to the office was decided upon.

I feel very diffident in having to follow so able a gentleman, and must ask you therefore to excuse my failings; but you may depend upon my services in my humble way being placed at the command of the Institute.

When quietly looking round for subjects upon which to address you, it occurred to me that you would not wish me to travel beyond the objects for which your Institute was established, and consequently that reference must be made to your rules and records for any requisite information. We find there ample scope and subjects, indeed far more than it would be possible to even touch upon under present circumstances.

The Chesterfield and Derbyshire Institute of Mining, Civil, and Mechanical Engineers was founded in the year 1871, when a few gentlemen in the Chesterfield district met together and decided to form the society. Some of these gentlemen have passed away, but we are still proud to have with us of those present at the original meetings Messrs. Oliver and Eastwood, and long may they continue members, helping forward, as they have always done, the objects for which the Institute was founded.

Some little time ago certain alterations were made to the rules by which members could be admitted at lower rates of subscriptions, and it was hoped this would induce many who were holding appointments in the management of collieries

below the principal manager to join us. To some extent this has been the case; but at the same time, providing they were aware of the benefits held out to them by so low a subscription, a greater number would in all probability have participated. It would not be out of place possibly to remind those gentlemen who could assist us, that we still hope to have a greater number of their superior assistants on our list of Associate Members; and also that they will, whenever an opportunity affords, place before others the advantages of becoming a member of the Chesterfield and Midland Counties Institute of Engineers.

Gentlemen, have we carried out the objects for which the Institute was established, or have we endeavoured to do so, at the same time maintaining our position amongst the other local mining institutes of the country? This you will allow must be answered in the affirmative; and that our members have written papers of great value that have been thoroughly appreciated by each of us. The discussions have been exhaustive, and men of great practical experience and knowledge have at these times been perfectly open and candid in their remarks, and whether they agreed with or dissented from the views expressed by the writers of the papers, it was understood they carried with them the weight of experience, and their remarks were listened to with great interest. Your records are a valuable addition to the mining literature of the day, and without unduly eulogising your efforts in this direction they may be consulted with both profit and advantage. A full set of your Transactions is a valuable addition to the library of any person engaged in mining operations, and doubtless the printed record has been consulted by many when difficult questions were submitted for their consideration.

Several exhaustive papers have been written upon the working and ventilating of mines, and the sorting of coal after being brought to bank. You have had valuable papers before you, with experiments on the effects of dust as an element in colliery explosions: the latter a most interesting and valuable contribution, and one which has been the means of directing the attention of many to a subject which up to that period had not received the attention and consideration so difficult a question required.

You can readily understand it would be impossible in this short address to travel very widely over the whole course of mining, but the subject of ventilation cannot be passed over without comment; and I need scarcely add is daily becoming a more important element in coal mining. "Once upon a time"—quoting from the old story books—it was considered sufficient at a colliery if, for ventilating purposes, a fire was lighted at the bottom of the shaft intended to act as an upcast and a sluggish current of air was caused to flow through the workings. The scene has now changed, and we find in our large and well-ventilated collieries hundreds of thousands of cubic feet of air per minute passing through them. Every stall and working place is well and sufficiently ventilated, the air being properly divided, and the science of ventilation brought to bear upon the general arrangement and its sub-divisions. A proper system of splitting the main current is organised, each split conveying a quantity sufficient for the district it is intended to ventilate without any one being of inordinate length and requiring extra pressure for that district alone. A single ill-arranged split in a mine will often prove a source of difficulty and danger, and one seriously affecting the general ventilation of the colliery. Above all, the air-ways must be of ample size and sufficient in area to convey the quantity required without undue friction. There are many paradoxes met with in the ventilation of mines, but I may venture to assert that good sized return air-ways kept well in order and up to the face, so that the ordinary friction of the air passing at the greatest distance from the motive power, will assist materially in solving some of these difficult and complicated questions.

Several papers have been read before you on the subject of mechanical ventilators, and the question has had its due share in your discussions. The "Battle of the Fans" is, I have no doubt, still fresh in your memories, and during those discussions much valuable information was elicited as to the relative merits of the Guibal and Waddle type. It has been generally understood that the effective power of the latter was somewhat less than that of the former, but my friend the late Mr. Waddle always maintained that, providing he could measure the water gauge at the same point in his that is generally done with the Guibal, the result would have given an equal percentage of useful effect. Quite recently, Mr. Capell has read before you a valuable paper on his ventilator, which received the attention from your members it deserved, and is an addition to the very short list of ventilators of real interest. I do not wish to discuss the relative merits of these, but it does appear to me (other circumstances being equal) that, presuming you could get, say 65 per cent. useful effect from the Waddle and Guibal and 75 per cent. from the Capell, you would naturally ask yourselves the question why you should not adopt the latter. The Guibal is very costly in masonry, the Waddle being less expensive in this respect, and it has been stated the Capell can be erected at a less cost than either, not only in this particular but also in the price of the machine itself. We have, most of us, erected the former two, and have therefore some experience to guide us; but even supposing that instead of 90 per cent. of useful effect claimed for the Capell, 80 per cent. could be obtained, you would certainly give it your attention before deciding upon the style of ventilator you would adopt.

Mechanical ventilators have been for many years past applied underground to assist in most cases in the ventilating of a difficult outlying district. The idea was discussed and freely commented upon by the members of the North of England Institute of Engineers some years ago, but it does not appear to have been very widely adopted. I do not suggest that the general ventilation of the mine should be accomplished by placing the machinery at the bottom of the upcast shaft, but it has been conclusively proved that a small machine in that position may be used to advantage for ventilating a difficult far-off district, assisting generally in the ventilation of the mine.

This question is daily becoming more important, as collieries working mines at a moderate depth are fast becoming exhausted, and in consequence deeper shafts with more extensive workings are taking their place. Many other reasons will occur to you why the furnace should be replaced by a mechanical ventilator, and in my opinion the time is not far distant when every well arranged colliery will be ventilated by this means. Looking upon the question from a commercial point of view there is really no reason why this should not be the case: the first cost of the furnace or furnaces frequently is more than that of a ventilator, and there cannot possibly be any question as to the latter being competent to execute the work at a less cost, and with great advantages in many other respects.

In the working of coal our old friend "longwall" still keeps to the front, and has not been superseded, neither do I think at present it is likely to be. Its home is in the Midlands, and, providing some person were to draw for it a genealogical tree, we should find the parent stem first took root in that portion of Her Majesty's dominions. We must not take credit to ourselves for having introduced it, for having inspected old workings of which no record of the period when they had been worked existed, we find that this same system had been adopted. It is quite true we have developed and extended the system as circumstances required, and it has been suggested that primarily the hardness of the coal was the cause of its being adopted. Whatever it may have been they, the originators, should have the honour, and as mining engineers we can quite appreciate their desire to create a way out of the difficulty.

The development of every mechanical means for reducing the manual labour employed in mines has of recent years received great impetus, and that this may still further be the case is very much to be desired. It is to the interest of both colliery owners and their workmen that we should by every means in our power relieve the latter so far as it is possible from excessive bodily labour, substituting for it mechanical means, thus allowing greater play for those faculties possessed by the miner, which the surrounding circumstances require should be fully utilised. This is especially the province of the mining engineer, and although much has been done there still remains a wide field to be operated upon.

Coal cutting machinery has for some years been more or less employed, but the increase in this particular direction has not been great. It seems a very simple matter to build a machine that would undercut a seam of coal, and thus relieve the workmen from the most laborious, and, I might also say, the most dangerous portion of their work. Still I cannot say it has been accomplished except in rare instances, and my own experience has not been satisfactory. The machines hitherto employed are in my opinion too large for their work, and it is scarcely necessary to point out how difficult and almost impossible it is to keep open a road of sufficient area alongside a longwall face.

Other labour-saving machines have been introduced, and amongst them may be mentioned the heading machine of Messrs. Stanley Brothers, of which a paper recently read before you gives a full explanation. In collieries where heading in the coal is a necessity, and headings are continually being driven, it would appear a useful application of mechanical science. Commercially it would be an important assistant, not only in the speed at which a road may be driven, but also by a reduction in the cost. We cannot fail when standing by men engaged in this description of work to have wished we were able to substitute other means, and it seems almost a disgrace that with so many clever and intelligent men amongst us this has not previously been done. Our members when they inspected the machine at work in the Nuneaton Colliery were quite satisfied as to its usefulness, and it is very desirable that such should be found to be the case.

The banking and sorting of the various seams of coal worked in the Midland counties has for long been a difficult subject, and has not until recently been solved with any satisfactory result. With the exception of those mines where the whole thickness was found to be pretty much of the same quality, or was sent away in the same wagon after being separated from the small coal, the work generally was carried out in a very primitive manner. This was principally owing to the fact of the mines in the Midlands requiring special treatment, and, to still further complicate the question, size does not generally constitute quality, and several descriptions of coal are also found in the same seam. The method adopted was not found to be satisfactory, and mechanical arrangements have in some instances been substituted for pure manual labour with satisfactory results. Quite recently a paper has been read before you by Mr. Timms on the system adopted at the Linby Colliery; and during the discussion which followed it was not alleged that any other arrangement was superior, or was better calculated to carry out the object in view. The belt, as explained by Mr. Timms, is there extensively applied, and so far as my experience goes it is an arrangement eminently adapted for these districts, the old method of attempting to manipulate the coal being found in practice impossible to be carried out with satisfactory results. The belt will in all probability be more generally applied, and may be so arranged that workmen can be conveniently placed on either one or both sides, as may be considered desirable. To work the system economically it will be necessary to construct the surface arrangements to meet the requirements of the case, this principally being that the tubs should be taken off the cage and

replaced at a level of sufficient height above what may now be considered the ordinary loading level. At this higher level the tubs may there be tipped into a shoot conveying the coal direct to the movable belt. The shoot should answer the double purpose of not only conveying the coal, but also when passing over it, taking out the small; and this may be readily done by having spaces arranged for it to pass through. There are obvious reasons for this being carried out, which will be appreciated by gentlemen having the management of collieries. Previous to the erection of any new plant, this part of the question will be fully considered by you, and possibly in a few years our pit banks will have assumed a different aspect, approaching somewhat in appearance to those we see so extensively in the northern counties. The emptying of tubs at the pit's mouth is still open to further improvement, it being very desirable that much of the breakage now caused by this process should be avoided. It is a very difficult question to carry through satisfactorily, and so far as I am aware no machine has yet been constructed that is not capable of improvement. Still we hope to see it done, and I am sanguine enough to think it will be solved by some member of our Institute.

Ambulance work at collieries, instituted by the late Colonel Duncan, was very early, if not first, taken up by this Institute, the result having shown how necessary such training of men at collieries must have been. Unfortunately, so long as mining continues accidents will occur, and consequently how desirable it appears that those having the supervision of mines should be competent to render first aid to the injured. It has been a means of relieving much pain and suffering that would undoubtedly have been endured had these classes not been instituted, and the time is not far distant when at every mine we shall see a number of the officials who have in their possession certificates from the St. John's Ambulance Society.

Having entered only very briefly upon portions of the science of mining that appeared to me not only interesting but very important, it is to be observed that it would certainly be quite impossible in an address of this character to even mention innumerable other matters that would interest you. The development of mining has been very considerable, and it is only necessary to point out, in order to show this to be the case, the returns of the amount of coal raised, which for the year 1888 amounted to upwards of 183,000,000 tons, being an increase of 10,000,000 tons over the preceding year.

When we consider the enormous sums of money invested in mining in this country, the whole of it being placed there by private individuals, how necessary it must be that those persons having charge should be fully educated for their work. This appears to me still further to be the case when we come to consider that not only are they responsible for the judicious and economical spending of the money in the first instance; but that they also have a great responsibility in regard to the workmen employed. It is not unusual to find from 500 to 800 men employed in a single mine, this fact alone proving my contention.

Our Institute has assisted so far as it has been able to disseminate knowledge and experience in mining matters for the benefit of all its members; the publishing of papers having in all probability assisted the advancement in various ways, and in many instances brought experience to bear with satisfactory results. The management of collieries has much changed, the supervision of late years has materially improved, and the appliances generally are superior to those of a few years ago, and in the future this will doubtless be still further the case. Consequently we find those having charge of mines gleaning information from any quarter that presents itself, and there appears to me every reason why we should further assist in the general development.

The mining course of lectures taken up by one of your members, Mr. G. E. Coke, was so far successful that many young men and others having charge of mining work, attended them. This question of technical education must, I feel convinced, be kept to the front by us, and although we have not been able to develop the idea, perhaps I may say, satisfactorily at present, still it will and must eventually succeed.

The course is being continued during the coming winter as a further trial, and for your support and assistance in this matter we specially ask.

The examinations for certificates of competency was I venture to say a step in the right direction, and for the first time in the history of mining in this country at last placed the man who had charge in his proper position. The granting under the Mines Inspection Act of second class certificates appeared desirable and has worked well. I have long however held the opinion that an examination superior to either of these should be held under Government control, the requirements being considerably in advance of those at present necessary to secure the certificate. Professors should be appointed who would meet annually either in London or in our provincial towns, they being able to grant a diploma that should rank in degree with those of our universities, and surely no better situation for such an examination could be found than under the shade of the noble building in which we are now holding our meeting. We must draw into the work young men of ability, and if possible they should pass an examination that would carry with it an important mark, and rank with those of the other learned professions.

The question of the Federation of the Local Mining Institutes of this country has so lately been before you, and so fully discussed, that it is only necessary for me very briefly to allude to it. A commencement has been made and in all probability valuable papers will be contributed, but in any case we shall have the advantage of a much wider field, and a considerably increased number of gentlemen as writers. In the future of this arrangement I have great hopes that the usefulness of our Institutions will be materially increased.

Gentlemen, there is a larger field of observation before you, and if we as a public body are to maintain our position we must keep pace with the times, it being scarcely necessary to again point out how very rapidly changes are being effected. I must therefore urgently ask each individual member to contribute his quota, and this can be done by his adding to our records, and during my period of office may I ask that there shall be no scarcity in this respect. Consequently it will be necessary that each member should bring to bear his influence and capabilities, when in the future, as in the past, your Institution will be useful, and recognised as being worthy of a place amongst mining institutes of the country.

A RECENT BORING AT CHESTERFIELD WITH THE DIAMOND DRILL.

BY G. E. COKE.

The Chesterfield Brewery Company requiring a further supply of water suitable for their wants, determined to make the experiment of boring in the hope of finding a water-bearing rock that is known to crop out on the top of Hady Hill.

A contract was accordingly made with the Aqueous Works and Diamond Rock Boring Co., York Road, Lambeth, and work was commenced early in February this year (1889).

The bore-hole was carried through the surface clays by hand in the ordinary manner, as the diamond drill only works to advantage in hard strata.

The diameter of the hole was 9 inches down to 64 feet, then 8 inches to 270 feet, 7 inches to 383 feet, and 6 inches to 421 feet 10 inches, where the boring was finally abandoned.

At a depth of 36 feet an open rock was passed through, and the water that is forced down the rods no longer rose to the top of the bore-hole, but remained from that time at a uniform level of 17 feet from the surface, until the bore-hole was completely lined with tubes.

On March 2nd, at a depth of 139 feet 10 inches, the boring was stopped in order to test the quality of the water from a feeder, and a pump was afterwards fixed to pump out the bore-hole and ascertain the amount of water.

The boring was resumed on March 21st, but frequent delays were caused by testing the water, and by having to line the bore-hole with iron tubes to stop back different feeders of water.

Finding that the water, instead of improving as the depth increased, became more saline and unsuitable for brewery purposes, the boring was finally abandoned on May 24th, in shales, at a depth of 421 feet 10 inches from the surface, and the tubes drawn out.

A section of the bore-hole is given (Plate I.), and it would be interesting if members conversant with the district would attempt to correlate the coal-seams.

This boring for a special purpose is, of course, no test of speed, but the nature of the strata always exerts a great influence.

Thus, in hard homogeneous strata, the boring proceeds rapidly, whilst in loose sand, clays, or greasy shales, the progress is slow.

From eleven different borings by the Diamond Rock Co. it appears that an average of 5 feet per day is accomplished, varying from :—

344 feet bored in 143 days, or at the rate of 2 feet 4 inches per day to 621 feet bored in 57 days at the rate of 10 feet 9 inches per day.

At Chesterfield, sometimes the boring was continued during the night, at other times by day only. A boring of 404 feet was accomplished in 67 days of actual work, and the amount bored per day varied between 2 feet and 12 feet.

A very good core of coal, 7 inches long, was obtained from the 4 feet 1 inch seam.

Plate II. shows the machine used at Chesterfield, and, although improvements have been made in the mechanical details of more recent constructions, still, in all essential particulars, the machine remains unaltered.

It consists of a frame (resembling pit headstocks) made of H-shaped wrought iron. This framework carries the machinery for boring, pumping, and raising the rods. The power is transmitted by belting from a portable engine, and applied

through suitable cogs and shafting. A power crab is attached to the machine for the purpose of lifting and lowering the rods by means of a chain passing over a pulley placed directly over the bore-hole and carried by shear legs.

A short length of rails is laid down for the reception of the machine to facilitate its removal during the process of drawing the rods.

The boring rods are carried and revolved by a vertical hollow shaft or rod, the lower end of which is supported and guided by a cross-head working in slides attached to the upright side frames of the machine.

This cross-head is given a rise or fall the length of the slides, and balance weights are attached to it by means of chains and pulleys for the purpose of regulating the pressure on the crown whilst boring. The upper part of the shaft is slotted to enable it to move upwards through the cog by which the power is applied, and on the top is placed a water union joined up to a force pump by means of flexible hose and iron pipes, the force pump being driven from the belt by suitable gearing. The boring tool (Fig. 2, Plate II.) is made up of the crown (*a*), core trap (*b*), core tubes (*c*), sediment tube (*d*).

The crown (Fig. 3, Plate II.) is a steel ring, cut with grooves to enable the water to pass away freely whilst boring. Nine diamonds are fixed in the crown—3 inside and 3 outside on the base, and 3 on the circumference.

The diamonds are placed in holes cut to their shape, and the metal of the crown is drawn round on every side by means of a punch, leaving only a very small portion of the stone projecting beyond the surface.

The crown screws into the core trap (Fig. 4, Plate II.), a short length of steel tube, the inside of which is slightly convex and fitted with an expanding ring which holds the core, whilst the tubes are being drawn. The core tubes are merely steel tubes threaded at the ends, of which one or more lengths may be used. The length of the core tube, of course, controls the greatest amount of boring between each drawing of the rods. In hard strata it appears that 20 feet is considered a convenient length of core tube, and this requires the shear legs to be a clear 40 feet in height. At Chesterfield the shears used were only 26 feet or thereabouts.

The top of the core tube is solid, with a threaded hole in the centre for the recep- of the boring rod.

The sediment tube screws on to the top of the core tube, and collects the sediment that is washed from under the crown. To reduce friction the core tube is slightly less in diameter than the crown.

The process for boring is as follows:—

The crown, core tube, etc., with a length of rod attached, as shown in Fig. 2, Plate II., are lowered into the bore-hole by means of the pulley on the shears, and are suspended by clamps over the bore-hole until one or more lengths of rods (which are merely tubes threaded at the ends) are raised in a similar manner, and screwed on to the clamped rod. The whole is then lowered, and this process repeated again and again until the crown reaches the bottom of the bore-hole.

The machine is then moved forward, the cross-head lowered, and the hollow shaft screwed on to the boring rods.

The boring is effected by a rapid rotation of the crown imparted through the rods (150 to 250 revolutions per minute), the pump at the same time forcing water down the hollow rods at a pressure sufficient to keep the crown cool and wash away the *débris*. The pressure used at Chesterfield was about 150 lbs. to the square inch.

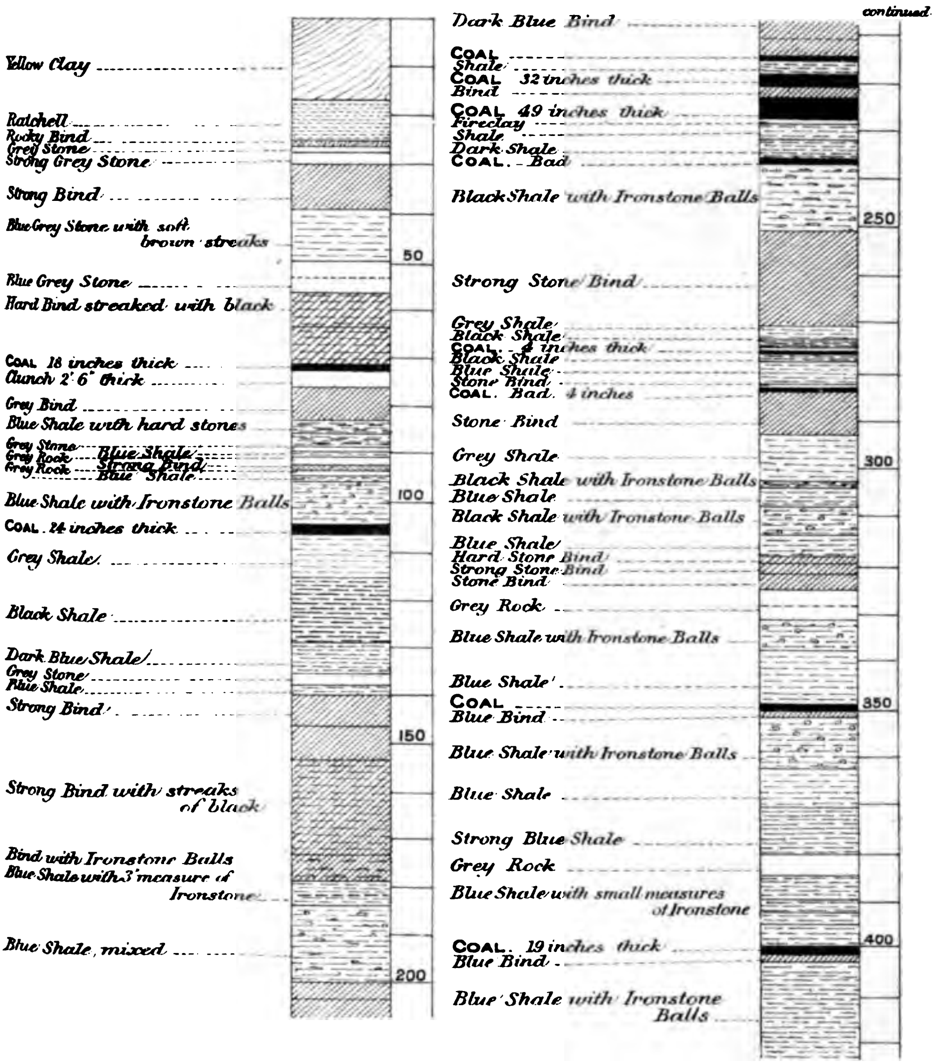
In reasonably strong ground a solid core is cut out, which rises in the core tube as the boring proceeds, and on drawing the rods it is broken off at the base and retained in the core tube by the expanding ring.

Proper receptacles should be prepared for these cores in the vicinity of the bore-

To illustrate Mr. G. E. Coke's paper on "A Recent Boring at Chesterfield with the Diamond Drill."

CHESTERFIELD BREWERY BORE HOLE.

SECTION OF STRATA



Scale - 40 Feet to one Inch.

Federated Institution of Mining Engineers
Proceedings 1889-90.

Andw Reid Sons & Co. Lithos Newcastle

To illustrate Mr. G. E. Coke's paper on "A Recent Boring at Chesterfield with the Diamond Drill."

Fig. 1.

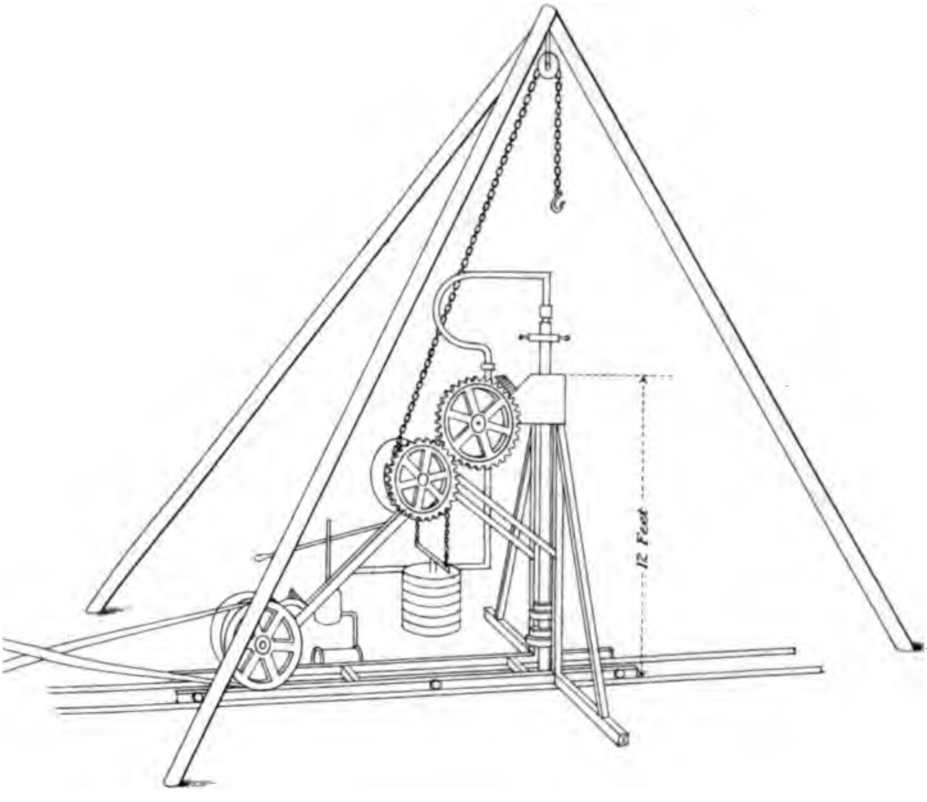


Fig. 4.

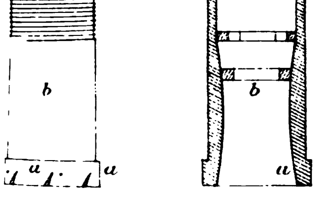
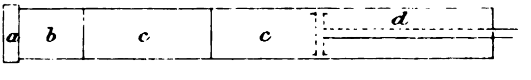


Fig. 2.



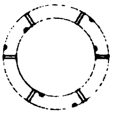


Fig. 3.

Not to Scale

Federated Institution of Mining Engineers
Proceedings 1889-90.

Andw. Reid & Sons Lith. Newcastle.

hole, and it should be clearly shown where any portion has not been extracted. At Chesterfield the power was supplied by one of Fowler's 12 horse-power portable engines, 12-inch cylinder, 1 foot stroke, and 45 lbs. pressure of steam.

Until the introduction of the diamond for boring the only way of dealing with rocks was by percussion, and in fact the diamond was at first thus applied, but experience soon showed that the strength of the diamond lay in abrasion.

The diamond used for boring is very different in appearance from the gem, and is never found in the same locality. It is a pure carbonate,* black in colour, and might easily be mistaken for coal. These carbonates, or rough diamonds, are found in Brazil, and are the hardest known substance in nature; thousands of feet of the hardest rock may be bored through without the carbonate showing any sensible wear.

The Diamond Rock Drill has also been employed for the following purposes:—

1.—Prospecting for minerals.
2.—Heading driving.
3.—Shaft sinking.
4.—Removal of sub-aqueous rocks.

In prospecting for minerals the solid core obtained by this method in reasonably hard strata is of great advantage. Thus at Battle, in Sussex, a bore-hole 1,906 feet in depth was put down by this same company, and geologists had no difficulty in defining the strata passed through, as many of the solid cores raised contained characteristic fossils.

The bore-hole is also kept true and vertical by the diamond drill, and this cannot always be depended on in other systems of boring.

The conditions of contract will probably be of interest, and are accordingly appended:—

Aqueous Works and Diamond Rock Boring Company.

General conditions for boring or prospecting for minerals.

1.—The work to be paid for monthly on a fixed day as it progresses at the rates mentioned in the accompanying schedule, the measurement in each case to commence from the surface of the ground.

2.—The employer to find water and engine power (which includes engine, fuel, and driver), or, should he prefer it, the company will find the engine power at a cost of £25 per month (an ordinary portable engine, say with an 11-inch cylinder is required).

3.—The company to find labour, machinery, and all tackle necessary for the proper carrying out of the work.

4.—The company does not bind itself to bore any specified depth, but will use its best endeavours to reach that required. (This clause is inserted as a saving one only, to provide against the contingency of meeting stratification which it might be impossible in any way to bore through.)

5.—The company will keep and deliver to the employer, or his authorised agent only, an accurate account of the depths of the borings, and of the nature and thickness of the strata passed through; and hand over to the employer, or his authorised agent, all cores that may be brought up of rocks bored, and mark and certify such cores, so as to preserve an accurate account of the strata.

6.—If a total amount of work of 500 feet or less be done, the cost of transport of the machinery to and from the site of operations will be charged. If the total

* Carbonate is the technical term in use. The substance is, of course, not a carbonate but carbon.—*Editor.*

amount of work is between 500 and 1,000 feet, then the cost of carriage to the site of the work only will be charged. If the amount be, in the aggregate, 1,000 feet or over, no additional charge made beyond the schedule prices, except in the cases mentioned in paragraph 7.

7.—If holes are put down to a depth not exceeding 250 feet each, the cost of shifting the machinery, etc., from the site of one hole to that of another, and re-erecting it, is to be defrayed by the employer.

8.—The company does not hold itself liable for any necessary damage to field or roads that may be caused in getting their machinery on and off the ground.

9.—The employer to find covering for machinery (if necessary), and shed for protection of men from the inclemency of the weather.

SCHEDULE OF PRICES FOR BORE-HOLES.

First	300 feet	... ...	10s. per foot.
Second	300 „	... ...	15s. „
Third	300 „	... ...	20s. „

Greater depths quoted for up to 3,000 feet.

These prices apply to work in strata of ordinary character.

The company will undertake work from the bottom of shafts, or continue bore-holes already commenced, in which case special prices will be quoted.

Should the nature of the ground to be bored through be such as to require lining, the expense of providing the lining tubes, and of putting them down, to be borne by the contractor; but should the company recover the lining tubes, the contractor will bear the expense of the recovery, but will be allowed 80 per cent. of the prime cost of the tubes.

No difficulty has occurred in practice in withdrawing the lining tubes.

Whilst the boring was in operation the Chesterfield Brewery Company courteously permitted anyone interested in mining to inspect the works at all times. And the writer also wishes to acknowledge the assistance he received from the officials of the brewery and boring companies in obtaining the necessary data.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD AT THE VICTORIA HOTEL, SHEFFIELD, ON TUESDAY, OCTOBER 15TH, 1889.

MR. C. E. RHODES, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected members of the Institute, having been previously nominated:—

Mr. J. H. TAYLOR, C.E., Borough Surveyor, Barnsley.
Mr. W. H. MILES, C.E., King William's Town, Cape Colony.
Mr. JOS. M. WILSON, Manager, St. John's Colliery, Normanton.

The PRESIDENT—I am afraid our business to-day is very brief, and for one great reason—we cannot get papers. This meeting is something like two months beyond the time that we ought to have had it, simply because we cannot get papers. I am very much afraid, if we do not get papers, that we shall have a good many of our meetings like this, and unless the members will help us, I am afraid the Council cannot do much towards making the present session a success. It is no use meeting for adjourned discussions of one paper or another. There is not much interest to be got out of it. They may do as secondary subjects, but we want papers to start the meetings. Mr. Walker has been a very useful man, and has assisted us from time to time, as he has sprung into the breach, and helped us in every possible way, but I am afraid that he will begin to get tired of it. I do hope before another meeting we shall have two good papers; and that before this meeting ends I shall induce some members here to promise one each. There is any amount of scope for papers. Mr. Arthur Chambers promised a paper on coke ovens, but he has been so busy he has not been able to get it prepared. Mr. Chambers, of Denaby, might be able to give us some useful information upon sinking, and I think, though he might give us some, we might give him in return information that he might make use of. In other directions there is ample material of interest and utility if we could get people to apply themselves to the matter in question, and I do hope you will help us and let us have one good meeting before the year closes.

The SECRETARY—Mr. Jackson, of Whitwood, has promised a paper.

The PRESIDENT—But that we have not been able to get yet. I do not know that I can say anything more. The question lies with you, gentlemen, to induce your friends to come forward, or to come forward yourselves and give us papers, or else it will be very little use our meeting, and we shall be simply an Institute in name. I think the mere fact of the Federated Institute choosing Sheffield for holding their first meeting is one that shows, outside our own district, we hold a position that ought to make us anxious to show by our Transactions and papers,

now that they are going to be printed and published and sent through the country, that our meetings are a credit to us, and the record of them worthy of being printed along with those of other Institutes, and I hope, therefore, the members will help us as a Council to send out something in the way of Transactions that will be taken up and read with interest by members of this Federated Institute, who have now an opportunity of seeing what we do.

Mr. G. B. WALKER—We shall have to have some papers for the Federated meeting. We cannot have meetings and no papers; the Midland Institute will have to provide some part of the programme.

The PRESIDENT—Yes; we must have papers for that. That meeting ought to be almost a two days' business, ought it not?

Mr. G. B. WALKER—One day indoor and one day outdoor.

The PRESIDENT—The morning we might have for outdoor, and in the afternoon a paper, discussion, and dinner.

Mr. G. B. WALKER—That is a matter for consideration. If many of them travel from the North on the day of the meeting, suppose the meeting is at three o'clock and we get it over by six, and then have dinner. That would do for the first day, and the second day let them split up and go to any collieries they like.

The PRESIDENT—I think that will be best.

DISCUSSION ON MR. MARSHALL'S PAPER ON "AN OUTBURST OF GAS AT MONK BRETTON COLLIERY."

The PRESIDENT—There has been another awkward explosion, although only on a small scale apparently, at Swaithe Main, resulting from gas in some way; but we have no data before us.

Mr. G. B. WALKER—I think a great many of the outbursts that have taken place in South Yorkshire have been in the Silkstone seam, and from the bottom of the Silkstone seam. We have had four at Wharncliffe Silkstone, and in two cases we have had several acres fouled. Since then we have been boring down about 14 feet or 16 feet, to the depth from which it was assumed the gas came. Mr. W. Hoole Chambers has a paper about a similar outburst at the Thorncliffe Collieries, and he will say if I am right in assuming that that was the depth from which the gas was supposed to come. After our outbursts we sank down as far as the rock was at all disturbed, and when we got about 15 feet down we came to a very hard grey rock. That did not appear to have lifted at all, but seemed to be quite solid and unmoved, and Mr. Wardell thought we need not go further. For two or three years now we have been keeping two men on boring in the two districts. We bore a hole at the end of every second gate and at certain intervals, and in none of these bore-holes have we ever got any considerable quantity of gas—just a little now and then, but never anything to account for those large volumes of gas which have been given off in our own pit, at Strafford, and at Tankersley. It would be a very curious circumstance if an outburst should occur after, as it were, tapping the thing so frequently, and not finding anything of moment.

Mr. A. M. CHAMBERS—We did it some years ago, with no result except spending some money.

The PRESIDENT—I think any remarks I had to make on this paper of Mr. Marshall's I made at the last meeting. I do not think there is any law to be laid down. What may hold good in one case is of no use in another; and there is no accounting for what may occur in coal. We are working a seam now with 700 yards of cover, an entirely maiden field, surrounded by untouched minerals for hundreds of miles, I suppose, and have never seen anything like gas in a heading or anywhere else, except a blower now and then. In another pit 200 yards nearer the surface you cannot drive ten yards without having the place full of gas. There is no accounting for it.

Mr. A. M. CHAMBERS—Sir George Elliot has put forward the theory that there is a gas zone: I am not sure of his figures, but I believe it was between 200 and 500 yards deep.

The PRESIDENT—He based his theory there, perhaps, because the largest explosions had been between those two points, ignoring the fact that nearly every large colliery was working between those depths when he made his statement.

Mr. A. M. CHAMBERS—We had a curious thing a short time ago, where the whole of the coal had been worked except a pillar—in bringing back that pillar we had an outburst of gas. It was not a serious one, but we had an area of goaf all round it that had been worked in short work.

Mr. BURNLEY—Did the gas come from the goaf?

Mr. A. M. CHAMBERS—No; from the floor. It always does so in the Silkstone seam. In the Parkgate it comes from the roof.

Mr. G. B. WALKER—The last outburst at Strafford came when they were taking a rib of coal alongside the goaf, a few yards thick only.

Mr. BURNLEY—You must have liberated the gas by working the coal out and giving it vent.

Mr. A. M. CHAMBERS—They must be very local. These places where gas is given off in these blowers must be very small comparatively.

Mr. W. HOOLE CHAMBERS—When I read my paper some time ago before this Institute, I pointed out that a great many of the outbursts we had had were within 300 yards or 400 yards of each other. I held then the same opinion which I hold now, that you might bore within 100 yards of the place where the gas came from, and might not tap the feeder you require to set at liberty; because where you had large outbursts with the indications we had, with the disturbance of the floor, it being heaved up to the roof, almost in a five feet seam, and yet within 300 yards and 400 yards had another outburst, it was a clear indication that there was no communication between one pocket of gas and another.

Mr. NASH—In these cases had you a substantial rib of coal between the two different goaves from which the gas came off, so as to form a sort of solid barrier between these two places?

Mr. A. M. CHAMBERS—Yes, that was so. Have you had any other outbursts in the dips?

Mr. G. B. WALKER—No.

Mr. A. M. CHAMBERS—In Rockingham we have not had more than one working entire longwall. We only had one which occurred after the faces got about a hundred yards up.

Mr. G. B. WALKER—Ours were just when you might expect the floor to yield in consequence of the amount of coal that had been got out of the pit. There is a terrible thing which will be of interest to this Institute at some time, that is the fire at Boldon; a most awful affair. I have not any information within the last three days, but on Saturday they had not got the fire anything like under, and the heat was so intense it was almost impossible to do anything with it, and they cannot apply water, for the working of the Hetton seam below was very extensive.

The PRESIDENT—It is a dreadful business if it has got fairly hold of the pit bottom.

Mr. G. B. WALKER—It is put out in the pit bottom; it is in the coal several hundred yards in-bye.

Mr. A. M. CHAMBERS—I heard last night from some one who saw Mr. May on Sunday morning, and he said they had just managed to isolate it.

Mr. G. B. WALKER—I am thankful to hear it.

The PRESIDENT—Nobody wants to have an extended practical experience of fire in a pit, and it is good indeed, therefore, if you can get it second hand. Mr. Chambers has had a large experience; I have had some, and certainly want no more.

Mr. A. M. CHAMBERS—Ours was comparatively a small affair. It was in sinking—firing a shot in the Parkgate seam which set it on fire.

The PRESIDENT—I am certain in nine cases out of ten, where a fire occurs in the pit bottom, there is no other way but water.

Mr. W. HENRY CHAMBERS—One fire we had was at the pit bottom. The flame came up the whole width of the road, and it would be about two feet deep thick. We could not face it, and we could not get in at the other end. We

made a bank of sand as far as we could until we filled the road up, then we got rakes and kept pushing it over, till we drove the fire back forty yards. We scoured it out and had no water to it at all.

Mr. G. B. WALKER—Was that burning coal or gas?

Mr. W. HENRY CHAMBERS—Burning timber and coal. We got the road filled up that way so that we could get as near as we could. Of course it put the flame out when we made it right up.

Mr. A. M. CHAMBERS—You did that pretty early, before it had got a big hold?

Mr. W. HENRY CHAMBERS—There would be 12 or 15 yards of it on fire.

The PRESIDENT—You were rather expecting it?

Mr. W. HENRY CHAMBERS—We are always expecting it.

The PRESIDENT—You had everything ready. It would take Mr. May, at Boldon, eight or ten hours before they could do very much.

Mr. W. HENRY CHAMBERS—We built a stopping until we got sand and everything ready, but the heat cracked the wall, which fell down long before we could get the sand there.

The PRESIDENT—It is a dreadful experience to have to go through. In a place like Boldon with all that timber it must be awful.

Mr. G. B. WALKER—There must be a tremendous current of air, which will make the fire burn more fiercely.

The PRESIDENT—We had one at Car House in the pit bottom, and at Aldwarke too, and the coal got fairly hold in both cases. We simply had to leave the fan going because we had our men in the pit and could not stop it, on account of the smoke given off being carried into the workings where some men had to be got out. We got to it with water, and air was necessary also to take the steam away. We had a good roof in each case. If it had been a bad roof I do not know what we should have done.

Mr. W. HENRY CHAMBERS—In our case we had 40,000 feet of air going where the fire was, and dare not stop the fan, because the gas showed immediately if you steadied it. When we banked it there was no current; it could not get to it.

Mr. BURNLEY—It is a good plan to stem the fire out if you can get to it.

Mr. W. HENRY CHAMBERS—We found it the best way. If you put water on it falls to a great height.

The PRESIDENT—I spoke of such a fire as you had in the pit bottom. When you have a fire in the pit bottom there is no chance of getting it out without water. It is impossible to wall it off with stone or anything else, especially where you have a large quantity of timber as you had there.

Mr. W. HENRY CHAMBERS—When it is in the dip workings, where you can conveniently get at it, it is the best way to get it out.

The PRESIDENT—Mr. Marshall, have you anything further to tell us?

Mr. MARSHALL—I was under the impression you had a meeting when I was away from home. I continued the boring a certain distance, and thought afterwards it would be no good to you. I can give you the information I obtained which is shown on the tracing.

The PRESIDENT—Mr. Marshall's tracing shows that the Oaks workings at the south side are stripped right up to the fault at one place. He has had a bore-hole put down below the Barnsley bed, and found no coal until he got 14 yards below it. He goes through a strong spavin and strong bind, and then gets to a coal which is 1 foot 4 inches thick, then 1 foot 8 inches of clod, and 2 feet 1 inch of coal, making a total of 3 feet 5 inches of coal. With an enormous area opened out such as there is, and with the throw there, it might account for any quantity of gas given off.

Mr. MARSHALL—There are 50 acres.

Mr. NASH—And the throw a natural barrier on one side.

The PRESIDENT—Yes; it is quite possible to account for the gas with the throw and the open space.

Mr. A. M. CHAMBERS—When you put the bore-hole down did you get gas?

Mr. MARSHALL—Yes, a good deal of gas when we got to the coal. I might say that at 12 feet we met with a soft dark bind which gave off a large quantity of gas.

Mr. T. W. H. MITCHELL—About three inches thick.

Mr. W. HENRY CHAMBERS—We had an outburst at Denaby seven years ago. I traced it to a seam of bind, and I believe it came from that. It was about 12 feet below the Barnsley bed in a shallow part of the pit.

It was ordered that Mr. Marshall's additional drawings be added to the former one of the same subject.

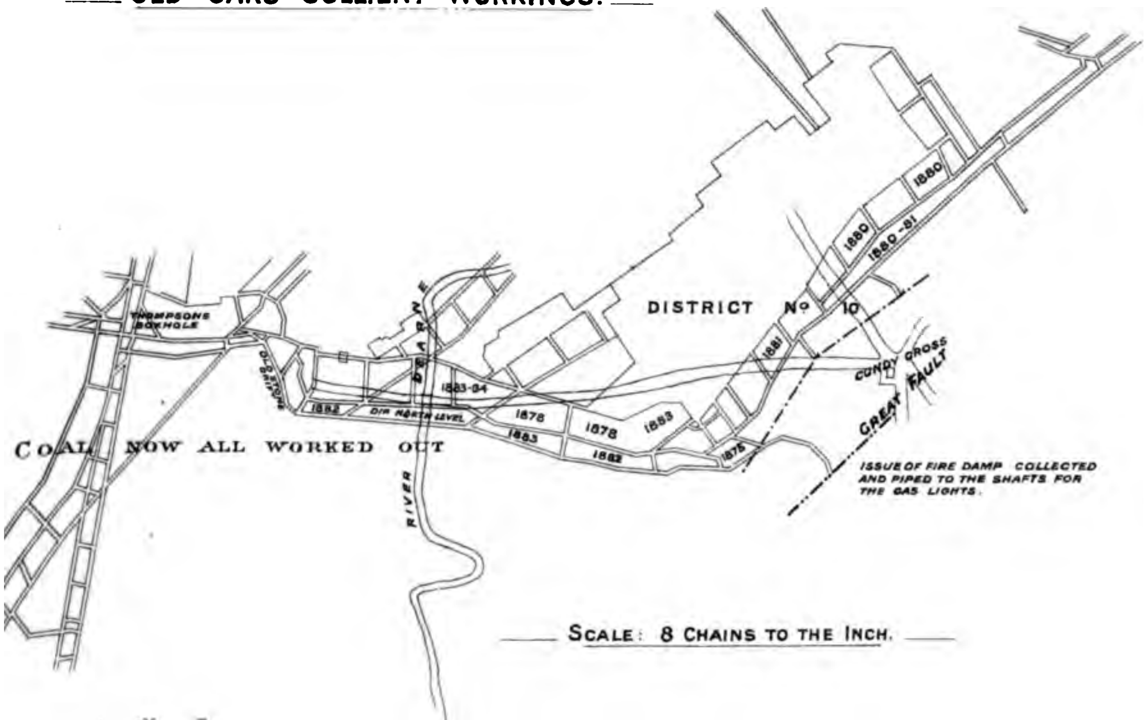
The PRESIDENT—Can I induce any gentleman to promise me a paper for the November meeting at Leeds? I should like to have a good meeting there.

Mr. W. HENRY CHAMBERS—I think our sinking operations at Denaby are in a preliminary state at present. There is not much information I can give you on that; if there is anything sufficiently interesting to make a paper of afterwards I shall be pleased to do so.

The PRESIDENT—Thank you. Then I do not know that we have anything more before us.

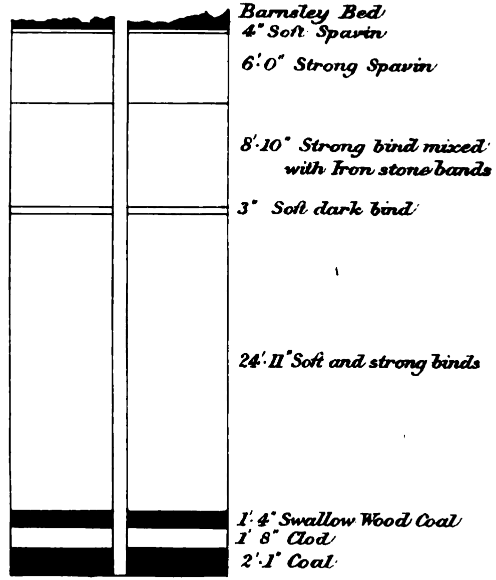
To illustrate Mr. J. L. Marshall's paper on "An outburst of Gas at Monk Bretton Colliery."

OLD OAKS COLLIERY WORKINGS.



SCALE: 8 CHAINS TO THE INCH.

SECTION.



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MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD AT THE QUEEN'S HOTEL, LEEDS, ON TUESDAY, NOVEMBER 12TH, 1889.

MR. JOHN GERRARD, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read a letter from the President, intimating his inability to be present at the meeting.

The following papers were then read:—

REPORT OF AN OUTBURST OF GAS IN THE HAIGH MOOR SEAM AT WHITWOOD COLLIERIES.

BY W. G. JACKSON.

As an example of an outburst of gas, the following report is submitted to this Institute in the belief that any such report will be of some interest to the members, whether it be large or small, as adding to some extent to the statistics of a subject that has lately been before the members, and possibly leading to further discussion of the matter, and to the communication of further and more valuable information on the subject.

The outburst of gas occurred on August 21st last, at about 9·30 in the morning, in the Haigh Moor seam at Whitwood Collieries.

The Haigh Moor seam lies at the shaft at a depth of 245 yards, and at the seat of the outburst at a further depth of about 50 yards.

The pit had always been worked with naked lights, no outburst having ever occurred before, so far as can be ascertained.

On reference to the accompanying plan (Plate I.) it will be seen that the outburst occurred between a nip-out through which a drift had been driven and a dip fault improved. Through the drift there was a wood brattice, as shown.

The amount of air going into the place was about 2,500 feet per minute. At the face of the main gate in the fault was a sump, about 5 feet deep, with water in it.

The man in charge of the place reports that he had just observed some slight indication of weight, as he thought, when he heard a rush of gas through the water in the sump, and from the floor where cracks were afterwards found. That the water in the sump rose from being about a foot below the level of the flat sheets to such a height as to cover them.

That on the first indication of anything unusual he shouted for all to come out, which they proceeded to do, but the gas fired on them before they had time to get further than on to the main gate.

The explosion blew the wood brattice down, smashing it entirely into small pieces, the brattice stoppings were blown down in the side gates, a door 140 yards back was blown down, and an overcast 400 yards back was blown up.

The ventilation was restored so far as to enable the place to be examined in about four hours after the explosion, when it was found that there was a crack running along the right hand face for about 20 yards, but no gas could then be found issuing from it or elsewhere. The place was quite still, the packs showing some slight signs of their having been a little weight on. The water in the sump had sunk back to below its level before the outburst.

Appended to the plan is a section of strata for a few yards above and below the seam, from which it will be seen that there is a 10 inch seam of coal about 8 yards below the Haigh Moor.

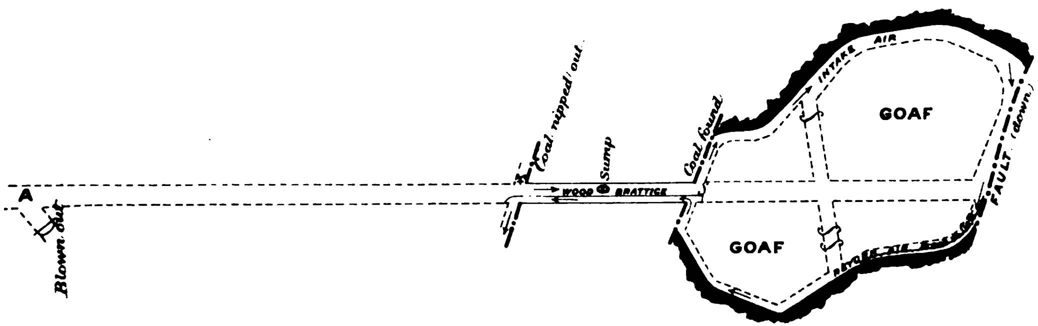
In conclusion, I would venture to suggest for discussion the question—Is any seam of coal safe enough to work with naked light?

To illustrate Mr. W. G. Jackson's paper on "An outburst of Gas at Whitwood Collieries."

WHITWOOD COLLIERIES

HAIGH-MOOR SEAM.

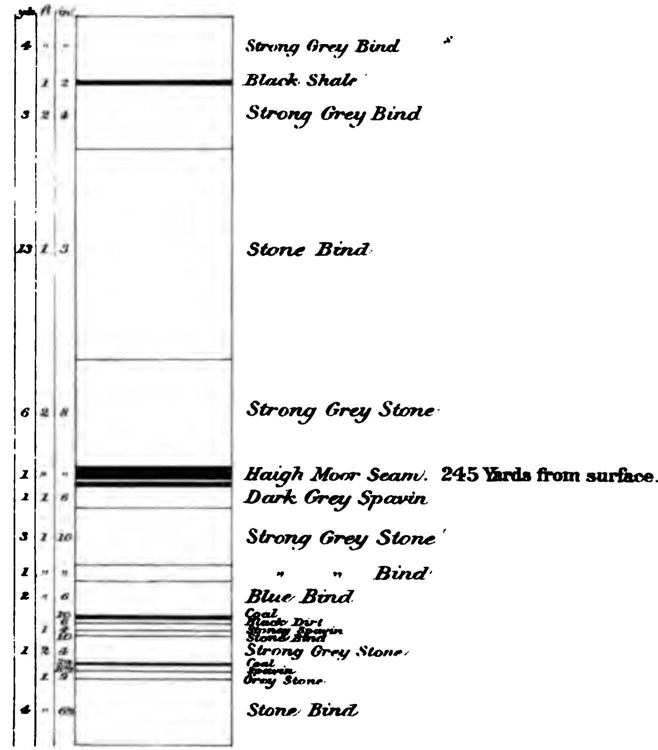
PLAN SHEWING
District in which explosion occurred
August 21st 1889.



NOTE. 267 Yards out-bye of point A an overcast was blown out.

SCALE. 150 LINKS TO AN INCH.

SECTION.



AN OUTBURST OF GAS AT HOUGHTON MAIN COLLIERY.

By J. Jarratt.

This occurred on the morning of April 17th, in the straight-in district of the south-east drift, at a distance of rather more than a mile from the shaft.

The night shift deputy left the district about 3 a.m., having observed nothing unusual except that he thought the district generally was a little uneasy; the datallers whom he left at work noticed nothing more during the hour and a half they remained in after being visited by him (the deputy).

About 6·30 a.m., when the morning shift of colliers was at work, a heavy "weight" came over the whole of the district, in consequence of which all the men came out.

These men were met by the day shift deputy, to whom they reported the reason for leaving their work. He at once made his way to the point marked A (Plate I.), where he heard a very heavy "weight" in the roof stone. Retracing his steps he examined gateways Nos. 1 and 2, and on returning towards the point A met gas at the end of No. 3 gateway, this having backed against the current of air which was 8,000 cubic feet at this point

He then examined the return air course at the points B^1 and B^2, and found it full of gas. The return was next examined at the point C, 1,530 yards from the point A (where the gas came off), and here also it was full of gas, and it was only after this return air had been joined by other returns and scales of quite fresh air that it was so diluted as to be harmless. Notwithstanding that an increased quantity of air was thrown into the district, and the speed of the ventilating fan increased, it was not until eighteen hours after the first outburst that the returns at the point C were reported clear.

Gas still continued to issue from the break in the roof-stone at the point A, this break being parallel with the working face, and continued doing so for many weeks after in gradually diminishing quantities until eventually it took up altogether.

There was no upheaval of the floor of the mine beyond that usually met with in our longwall faces, and I am quite clear as to the gas coming from the roof, not from the floor.

The district is a new one advancing into virgin coal, with an area of about two and a half acres of goaf, and up to the date of the outburst there had been no great indications of gas.

The Chairman—You have two very interesting papers submitted to you, communications of simple facts in connection with the most important subject of the giving off of gas suddenly in large quantities. Before submitting to you the questions whether these papers should be printed and appear in the Transactions of the Institute, before submitting also to you a vote that these gentlemen who have so kindly prepared and submitted these papers should be thanked by the meeting, I think it would be well to have some little discussion, as far as it is possible, upon these papers. Here you have two classes, one of outburst from the roof, the other from the floor. No doubt a third class, in which the gas has come from the coal itself, has occurred in the district. I hope if anything of that kind does take place it will be brought before the Institute, so that we may acquire a collection of facts with regard to this important question. I think Mr. Hoole Chambers has had some experience with regard to outbursts.

Mr. W. H. CHAMBERS—The only thing that strikes me about the two outbursts is this—in both cases they appear to have occurred very shortly after the coal has begun to be worked, practically as a new seam. When I first read a paper on outbursts of gas I expressed the opinion which I hold very strongly still, that to work the coal by the longwall method of working was a great preventative of outbursts of gas. At that time I was controverted by several members of the Institute in some particulars, by many working the coal on a different plan. But as far as our experience is concerned at the Rockingham Colliery, where we have worked longwall, we have had only one outburst of gas, and that was when opening out. Since then we have not seen anything like an outburst, although working the same seam, under the same conditions in every respect as those we worked formerly at Tankersley, where we have had many outbursts of gas. Where you are practically opening a new seam of coal, with no connection with any other seam, when you first begin to open out, when you have cleared a sufficient area to allow the gas to find vent, it comes off with considerable vigour, and shows itself in such a manner that it competes with any ventilation you may bring to bear upon it. I should like to ask Mr. Jarratt if he could give us any information as to the quantity of air passing at the point C mentioned on the plan?

Mr. JARRATT—I do not know offhand what passes there with all the other splits.

Mr. W. H. CHAMBERS—If one knew the quantity of air, and it takes 18 hours for that to get below explosive point, one might arrive at the quantity of gas given off.

Mr. JARRATT—There is a much larger district that was ventilated with another split to the dip. That would have to join the return, and so the air passing down would be certainly 10,000 feet.

Mr. W. H. CHAMBERS—We had an outburst in which the gas came against a current of 30,000 feet for a considerable distance.

Mr. JARRATT—I may say, with respect to Mr. Chambers' remark about working longwall, I think his argument is that old districts do not there show outbursts of gas, or are not so liable to them as new ones. Is that it?

Mr. W. H. CHAMBERS—Yes.

Mr. JARRATT—Five years ago we had an outburst at Houghton Main in a comparatively old district—it was about four years old—and we were just about closing it when we had the outburst, so that one may argue from this we are as liable in an old district as in a new one.

Mr. BENNETT—It would be interesting to know how the goaf had broken prior to this outburst, whether it was standing back or not.

Mr. JARRATT—We had had breaks, though the goaf was very small. They had all broken in due course; there was nothing singular in respect to the fracture of the roof beforehand at all. This had progressed steadily without any interruption whatever.

Mr. BENNETT—I suppose this would be what we should call the first top weight?

Mr. JARRATT—Yes.

Mr. BENNETT—I have seen cases where gas has been brought off in something after the same way when they have been started in a new district, something in the style of this one, and it has been really the top weight coming on that has brought off the gas.

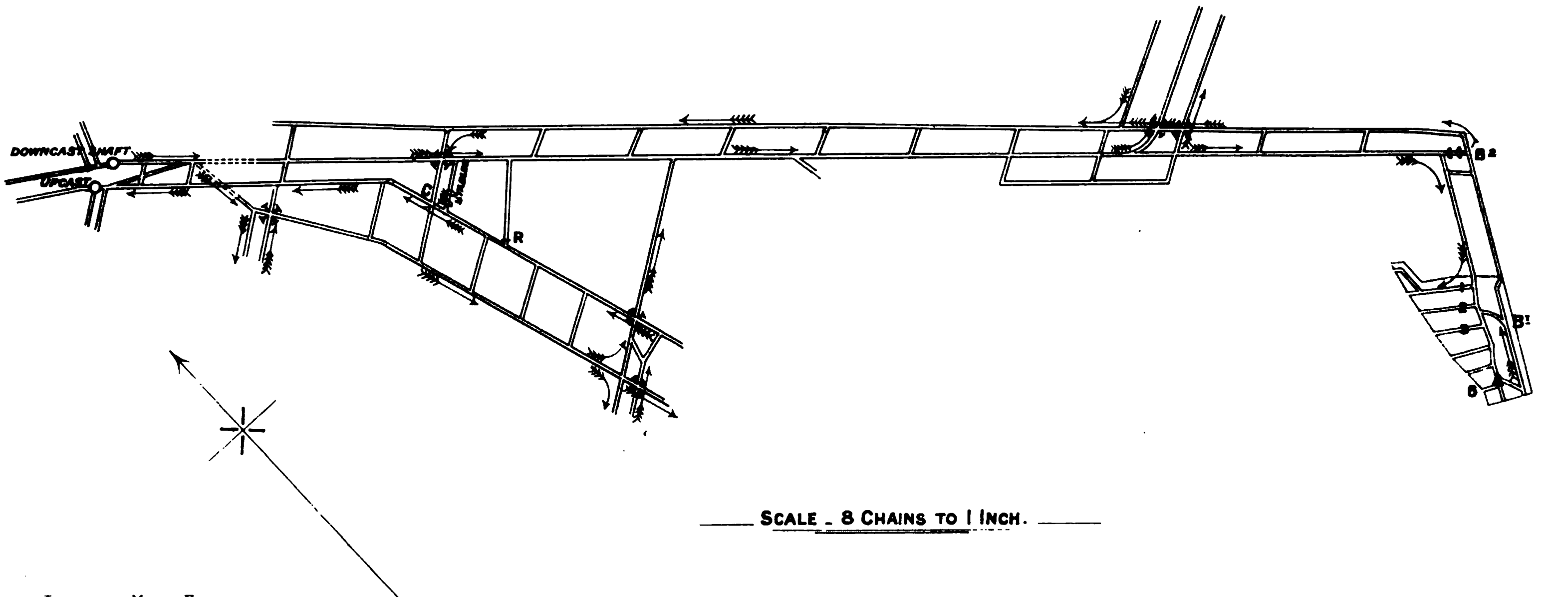
The CHAIRMAN—I am sure the Institute would be indebted to you, if you have any such occurrences, if you would bring them before the Institute, so that we could get as full and complete a collection of facts connected with them as possible.

To illustrate Mr. J. Jarratt's paper on "An Outburst of Gas at Houghton Main Colliery."

Houghton Main Colliery

Plan accompanying

Report or Outburst of Gas in the East Level Rise District. April 17th 1889.



SCALE _ 8 CHAINS TO 1 INCH.

Federated Institution of Mining Engineers
Proceedings 1889-90.

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Two points have been alluded to, both practical and important, one being the area of the goaf and the other the subsidence or settling of the roof. Both are points which are worthy of some attention.

Mr. BENNETT—Although the pressure comes from the floor in one case the cases are very similar.

The CHAIRMAN—If there are any points Mr. Jarratt can supply further information upon, he would be pleased to give them his consideration with a view to their being added.

Mr. JARRATT—Yes; the area of the goaf is mentioned.

The CHAIRMAN—That is not the point I had in my mind. Should any question be asked, if you are not in a position to answer now, you would get the information.

Mr. JARRATT—I could readily ascertain by reference as to what Mr. Chambers remarked as to the quantity of gas passing the point C (Plate I.).

Mr. W. H. CHAMBERS—There is a very interesting matter suggested by Mr. Jackson's paper, and that is, is it safe to work any seam with naked lights? I think that would make a very interesting discussion, one in which we might have a good deal of information brought to bear. We had some reference made to this matter at our last meeting in reference to a zone of gas being arrived at between 200 yards and 400 yards deep. We have the depth of this seam given which places it in the zone where gas is found most frequently; I think the question whether a seam is safe to be worked in the present day at anything like that depth with naked lights, is one which should specially occupy the attention of this Institute, because, in my opinion, I do not think it is safe to work any seam with naked lights.

Mr. GARFORTH—May I enquire who has raised the theory of a zone of gas?

Mr. W. H. CHAMBERS—I believe Sir George Elliot.

Mr. GARFORTH—Do we understand from that that gas may not exist in large quantities up to 200 yards, and that after 600 yards we may not expect to find it?

The CHAIRMAN—Sir George Elliot brought the matter forward in a paper read before the North of England Institute some years ago, in which he divided coal-mining up to that time into three zones—first, comparatively free from gas, surface workings; the second in which gas was found to be given off freely; and the third zone, which, he submitted, up to that time, had not been found to give off gas so freely as the second zone. He advanced one or two theories to account for them.

Mr. W. E. GARFORTH—It is generally understood that we meet with gas in as large quantities at 200 yards as at 800 or 900 yards. I do not know as to the zone. A good deal has to do with the nature of the roof. Some roofs are formed of compact shales, and others open and porous. These generally contain less gas than the shale. But, after all, the quantity of gas given off by the most gaseous seams is not so great as to form outbursts like some of the outbursts mentioned in South Yorkshire. It is accumulation which has led to the large quantities, and the question is, where does the accumulation come from when all the roadways in that particular seam are well ventilated? In the case of Aldwarke Main, 40,000 feet of gas came off for eight or ten days, and that means a very large area of pent-up gas. I should like to ask Mr. Jackson where he thinks the gas came from?

Mr. JACKSON—I think it came from a little seam below.

Mr. GARFORTH—Eight yards below, I notice.

Mr. JACKSON—Yes; I think it came from there. There was no great quantity really.

Mr. NICHOLSON—I believe Sir George Elliot drew his deductions from the fact that outbursts had occurred at collieries at 300 yards deep, but collieries at much

greater depth were found not to give off any great quantity of gas: at any rate no great explosions or outbursts of gas had occurred in them. I think he deduced that generally. I do not think that he examined or gave an account of all the particular seams at those greater depths. I should think that data might be got from the annual reports of the inspectors.

Mr. BENNETT—It was in his evidence before the Royal Commission at one time I remember.

Mr. GARFORTH—He gave that evidence in 1869 on the probable duration of the English coal-fields.

Mr. NICHOLSON--It was afterwards that he spoke of the different zones.

Mr. GARFORTH—Many people think they are connected with the system of working.

The CHAIRMAN—My own view is that we ought to get our facts first before we formulate any theories, because we have these outbursts occurring in three forms—from the roof, from the seam, and from the floor. We have them, as is shown by our collection of papers, from small areas, either newly opened out, or, so to speak, a new area adjoining an old area. There are several striking cases of that kind. Given certain conditions under which outbursts have occurred, what precautions can be taken to prevent an outburst occurring again under similar conditions? Whether it be by laying out the workings on certain lines, or by boring holes, it is a most important matter for a meeting like this to discuss, with a view to arriving at some line of conduct.

Mr. GARFORTH—I have already described how we had outbursts regularly until we put bore-holes down. It was a common thing to have outbursts of gas owing to a seam varying from 10 feet to 16 feet below the main seam, which was not worked. The intervening strata was lifted, a cavity formed, and when the weak point was reached, formed by the consolidated pack pressing the strata and forming a break, we had a sudden outburst. It was not until we put down two or three hundred bore-holes that we ceased to have outbursts; but when we had got them, we conducted the gas to particular points where we wanted it, and it was carried by the ventilation in the ordinary way.

The CHAIRMAN—You drew it out gradually?

Mr. GARFORTH—Yes.

Mr. W. H. CHAMBERS—May I ask if Mr. Jackson ascertained whether the strata below the seam were broken?

Mr. JACKSON—No.

Mr. GARFORTH—But there is a fault close to?

Mr. JACKSON—Yes.

The CHAIRMAN—In connection with other outbursts holes have been put down, and the ground is found to be lifted so that a hand could be put into the spaces.

Mr. NICHOLSON—I remember an outburst of gas in 1880. An area of coal had been worked, and afterwards their workings commenced to follow up what had been worked previously, that is, on one side of the goaf, and the top came on the weight. Just about that time there was an outburst of gas, and it was well proved, since the floor was lifted up for a great number of yards, and gas was issuing out of it like steam from a boiler, and an explosion occurred at the same time. That was in the Middleton Main seam of coal, and was accounted for, similarly to the case Mr. Garforth has referred to, by a seam of coal lying about eleven yards below the Middleton Main. I have no doubt the breaking point of the floor had been reached when this occurred, and gas came from this coal below.

Mr. GARFORTH—I think we might argue that with open lights you should put down bore-holes, but with safety-lamps there is not the same necessity. Wherever

an outburst has taken place I think bore-holes should be put down to prove any underlying seams.

Mr. W. HENRY CHAMBERS—To what depth would you put them down?

Mr. GARFORTH—At the Sovereign pit belonging to the Wigan Coal and Iron Company they put down 42 feet, and I saw 50 lbs. registered.

Mr. W. HENRY CHAMBERS—I do not think it is at all conclusive that the outbursts come from the seam of coal. I rather agree with the opinion Mr. Marshall expressed at the last meeting, that frequently there are outbursts from upheaval of the floor that do not come from another coal-seam, but are given off from the bind.

Mr. GARFORTH—Yes; but the point is the quantity given off. When Mr. Lindsay Wood proved by boring in the solid coal that he could get a pressure of 360 lbs., he could never get above 15 cubic feet per hour with that pressure, showing that with the greatest pressure you cannot get quantity. In the outbursts mentioned here you have a large quantity and not much pressure. The question is, where does the large quantity come from?

Mr. W. HENRY CHAMBERS—Wherever there is an outburst means should be taken to ascertain how far below the seam the gas has accumulated or been given off, so as to guide us in working the seam in other places, and how far we ought to bore to tap it.

Mr. GARFORTH—In some systems of working bore-holes are not advisable, as you could not tap the part. It is only where you have a large area.

Mr. NICHOLSON—In a large area bore-holes are advisable, as gas may be given off from the floor which may be lifted.

Mr. GARFORTH—I suppose you will have the communications put on record in the usual way?

The CHAIRMAN—I should say so without doubt, but thought it well to have some discussion. Has Mr. Marshall any further information respecting his outbursts?

Mr. MARSHALL—I have no more than I have already given.

Mr. GARFORTH—Was a pit sunk?

Mr. MARSHALL—A bore-hole was put down.

Mr. GARFORTH—Did you find anything?

Mr. MARSHALL—We put a bore-hole down a few feet and came to a strata of soft bind which gave off gas, and then went to the seam below, 13 yards down, which gave off a considerable quantity of gas.

The CHAIRMAN—Gas came from both bind and coal?

Mr. MARSHALL—Yes.

Mr. W. H. CHAMBERS—Mr. Routledge has recalled to my mind a case at Woolley. We sank 18 feet and found the bottom still broken. We could not get to the bottom, but found no seam of coal.

Mr. GARFORTH—We had some broken strata 16 feet above the coal. We filled it with oil, and then sank after it and found certain cavities in which the gas could accumulate.

Mr. W. HENRY CHAMBERS—If the upheaval of the floor takes place gradually it will make cavities which could hold gas in large quantities before it burst out and escaped.

Mr. GARFORTH—Mr. Jackson thinks the gas has come from the seam below; I think so too when I see the sketch and see the distance—about 8 yards to the underlying coal. We have had three instances mentioned of gas coming from the floor.

Mr. ROUTLEDGE—At the time of this outburst at Woolley Colliery, I was under Mr. Chambers. At five o'clock in the morning the night deputy examined the longwall face and found everything clear. The men went on at six o'clock,

and had worked half an hour, when it went off with a crack. They looked at their lamps and found them filled with gas, and they had the good sense to turn the wicks down and put them out, but it affected every lamp. They came for me; I found the faces full of gas and withdrew the men. Two hours after I sent for Mr. Chambers and it was all clear. At twelve o'clock it came off again. We sank down 15 feet, and thought we had got to the bottom of the cracks. We went again on Sunday morning, and sank from 5 to 6 feet, and did not get to the bottom; so that there had been an upheaval between our sinking on Saturday and again on Sunday.

The CHAIRMAN—Was the second outburst at the same place as the first?

Mr. ROUTLEDGE—Yes; anglewise against the face.

The CHAIRMAN—What was the form of working?

Mr. ROUTLEDGE—Longwall, and it had been going on for years.

Mr. W. HENRY CHAMBERS—That district had been open ten years at least.

Mr. GARFORTH—Could Mr. Chambers get the information for the Institute? It is a long time since we had a paper from him.

Mr. ROUTLEDGE—I made a sketch of it, and I think I have it somewhere.

Mr. W. HENRY CHAMBERS—At Denaby there has been one outburst since I have been there, perhaps five or six years ago, in the east plane district. That is worked longwall, and had been working since about 1870, a period of eighteen or nineteen years, and there had been two outbursts in that district before. It is a large area, and all the coal is taken out.

The CHAIRMAN—I should not wish to be misunderstood with regard to a small area. It is a fact that in the collection of papers, "Narratives of Sudden Outbursts of Gas," we give several cases where outbursts have occurred in connection with small areas. I did not mean to say that outbursts did not take place in connection with large areas, because that is also a fact. But if you can arrive at a line of conduct with regard to one; if you can be pretty clear that in opening out small areas we are more liable to these discharges of gas, under certain conditions, we may fix on precautions to be taken. If you put in the most approved form of safety-lamp, you do not care to submit them to such a strain as is evidently from such large quantities of gas liable to be thrown upon them. Although we may do as Mr. Jackson suggests, it is a conviction in his mind now that in mines approaching the depths of his, at any rate, no naked light should be permitted.

Mr. JACKSON—I did not say so; I suggested the subject for discussion.

The CHAIRMAN—Then it is not a conviction, but his mind is open to conviction upon that point, At any rate, even with the most approved safety-lamp, we would not care to submit it to such a strain as is involved in connection with these outbursts of large quantities of gas.

Mr. W. H. CHAMBERS—I move that the papers be printed and appear in the Transactions, and that the thanks of the meeting be given to the gentlemen who have contributed them.

Mr. PEARCE—I have great pleasure in seconding it. There is one matter which may be mentioned. In Mr. Jackson's case it is an outburst near some large faults, the other has no connection with faults.

Mr. JARRATT—No; quite clear.

The CHAIRMAN—Mr. Marshall's case was near to a fault.

Mr. MARSHALL—Yes; quite near to a fault.

Mr. ROUTLEDGE—I do not understand what was meant by putting lamps in at a certain depth. I can give my experience. We are under 200 yards deep, and never have gas except at a fault. But we have had many faults lately, and I have put lamps throughout on that account.

The CHAIRMAN—The conditions of coal mining are so varied that it is impossible to fix upon one theory to meet all conditions. It seems to me to be one of the greatest possible advantages connected with an Institute like ours, that, having facts before us, we arrive at opinions and convictions without loss of life. The experience of one is made known to others, and becomes the experience of all.

The motion that the papers be printed, and that the thanks of the meeting be given to the authors, was carried. It was also ordered that the discussion stand adjourned until the next meeting.

The discussion on Mr. W. E. Garforth's paper on "Artificial Foundations and Methods of Sinking through Quicksand" was adjourned till next meeting.

Mr. W. H. CHAMBERS—I move a vote of thanks to the Chairman for the able way in which he has conducted the meeting. It is always a pleasure to have our inspectors with us, and our chairman has given us every pleasure and satisfaction in the way that he has conducted the business of this meeting.

Mr. GREAVES—I have great pleasure in seconding it. I am very glad to see Mr. Gerrard in this position, and hope to see him in it many times.

The motion was carried.

The CHAIRMAN—I can only express my gratitude if my feeble efforts to conduct the meeting have met with your approval. I hope the vote of thanks will not appear in the Transactions.

Mr. W. H. CHAMBERS—Certainly it must.

The CHAIRMAN—It is scarcely scientific.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING.

HELD AT MASON COLLEGE, BIRMINGHAM, ON OCTOBER 3RD, 1889.

MR. HENRY LEA IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The SECRETARY, Mr. Alexander Smith, reported that Mr. Sopwith attended the first Council Meeting of the Federated Institution in Newcastle-on-Tyne, on Wednesday, September 11th. Mr. Sopwith was prevented from attending to-day and stating what was done at the meeting of the Federated Institution Council, and had therefore sent an explanatory letter, in which he stated that the questions raised by this Institute were waived for the present, it being thought that any alterations could be best dealt with by a sub-committee, or in some way after the initiation of the new Institution. He further remarked that Mr. John Hughes had been elected a co-optated member of the Council, and himself a member of the Publication Committee.

Mr. Walter Glennie's paper on "Notes on Mining in North Mexico" was on the agenda for this meeting, but as there were but few members present, the question was raised whether the reading of the paper should not be postponed. Mr. Glennie expressed his willingness to read the paper then if the members wished it. After some further conversation, however, it was moved by Mr. Peacock, seconded by Mr. Whitehouse, and carried—"That, in consequence of the few members present, it is desirable to postpone the reading of Mr. Glennie's paper until some future meeting—say the first Thursday in November."

The SECRETARY read two communications from the Council of the Mason College—(1) thanking the Institute for their donation of £10 10s., and (2) acknowledging the receipt of copy of Transactions of the Institute.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING.

HELD AT MASON COLLEGE, BIRMINGHAM, NOVEMBER 7TH, 1889.

MR. W. B. SCOTT IN THE CHAIR.

The minutes of the last General Meeting and Council Meeting were read and confirmed.

The SECRETARY reported that Mr. Sopwith and himself attended the meeting of the Publication Committee of the Federated Institution of Mining Engineers at Sheffield, on Thursday last, October 31st. It was stated at the meeting that 730 of the members of the North of England Institute, 260 of the Chesterfield Institute, and 170 of the Midland Institute had joined the Federation. Up to the present time only 33 members of the South Staffordshire Institute had joined. Altogether, therefore, there were nearly 1,200 members of the Federated Institution. Arrangements were made with regard to the publication of the Transactions, which it was decided should, if possible, be issued bi-monthly, commencing from the 1st of October last. It was also explained that arrangements had been made for the first General Meeting, which would be held in Sheffield in January next. There would be three very important papers—one on the Geology of the Sheffield District, probably by Professor Green, of the Geological Survey, who had paid special attention to the district, one on Coal-cutting Machinery, and one upon Pumping by Electricity. On the second day of the meeting members would have an opportunity of visiting a colliery, where they would see 16 or 17 coal-cutting machines at work, and also another colliery where the electrical pumping plant was at work.

Mr. WALTER GLENNIE then read his paper on "Notes on Mining in North Mexico."

NOTES ON MINING IN NORTH MEXICO.

By Walter H. Glennie.

When I left England for Mexico two years ago I promised that if any points of scientific interest came under my notice during my stay there I would impart them to the Institute.

I am afraid that I have met with very little, if anything, new to science, but I have thought that a few remarks on the mining of the locality, especially as regards native methods and processes, might prove of sufficient interest to warrant me in laying them before you: more particularly they may be useful to the younger members, some of whom may probably have occasion in the course of their careers to be connected with enterprises in foreign and rough countries.

At the outset, however, let me guard myself and members generally from possible misconception by cautioning them to bear in mind when I am speaking of customs or people, that I am referring specially to the comparatively limited district of which I have personal knowledge, and that many of the cases will only apply in a very general manner to the people as a whole. For Mexico is a large country, some 1,600 miles in length by 650 miles at its widest part: with every diversity of physical formation, from lagoons and swamp lands of parts of the coast, immense plains on the table-lands—fertile or barren as they may chance to be, supplied with water or not—up to some of the wildest and most precipitous mountains in the world: possessing also every variety of climate, from intense tropical heat on the coasts to the cold of perpetual snow on some of the mountain tops, with corresponding forms of vegetation and animal life. A moment's reflection, therefore, will make it plain, how great may be the variation of customs and character in different districts of a people who, as late as the time of the conquest by the Spaniards, consisted of a great number of independent nations or tribes, each with distinct customs and languages, whose descendants mixed with the Spanish blood have lived and are living under such diversified conditions.*

The great physical feature of the country is the main mountain range, the Sierra Madre, a continuation of the Rocky Mountains of the Western States of America, which runs through the whole length in a N.W. and S.E. direction, about quarter of the width of the country from the Pacific coast and more or less parallel to it, attaining an average elevation of 9,000 to 10,000 feet above sea level. The descent on the Pacific side is rapid and well watered with numerous streams and rivers, but to the eastward, more particularly in the northern part, extend a series of elevated plateaus, averaging some 6,000 feet above the sea with comparatively few rivers of importance, and intersected by subsidiary ranges of mountains running generally parallel to the main Sierra.

The Mexican Central Railway runs down the middle of these plains from the United States frontier at El Paso to the city of Mexico, and several other lines with extensions and branches are made or under construction in different parts of the country.

The place where I was located was the village of El Magistral, 3 miles from the small town of El Oro, in the northern part of the State of Durango, about 120 miles S.W. from Jimenez Station, on the Mexican Central Railway, 6,300 feet above the sea, and in the midst of one of the subsidiary ranges to the east of the Sierra Madre, of which I have spoken. This range forms a belt of mountainous country

* Don Antonio Garcia Cubos in his *Republic of Mexico in* 1876, tabulates 108 distinct Indian languages still extant.

10 to 12 miles wide of steep hills and valleys of 600 or 700 feet difference of level, running generally N.W. and S.E., with a strip of plain on the east side, and another plain or wide valley with a river in the middle, at about 1,000 feet lower level on the west. Across this belt run innumerable "arroyos" (watercourses), in most cases dry in the dry season, falling into the river in the valley below.

The hills consist of numerous varieties of trap, porphyry, quartzite, and other volcanic or metamorphic rocks, lying in beds at high angles, dipping generally to N.E., and much contorted and broken up in places. Through the village of Magistral, however, runs a junction line between these rocks and a red conglomerate, dipping at a moderate angle S.W., and overlaid with variegated red and green marls, all very similar in appearance to Permian, but further to the S.W. the traps and porphyries are again thrown up. In some parts of the district to N.E. there are fragmentary portions of a kind of slate mixed in among the traps. Considerable extents of micaceous rocks occur, and in one place is a blue limestone lying nearly horizontal, similar in appearance to blue lias but without any fossils that I could discover. Indeed, I have found no fossils of any kind in the district except a few corals in some pebbles, in one of the watercourses, of what looks like mountain limestone, but I know of no mountain limestone *in situ* in the neighbourhood.

The tops of many of the higher hills are capped with an unstratified stone ("cantera"), apparently of volcanic origin, showing a formation in many places of immense vertical hexagonal or octagonal columns, composed of particles of all sorts of rock ground up and mixed together, often honeycombed, very light, soft, and easily worked when first got out, but afterwards hardening in the atmosphere.

The general geology of the district puzzled me exceedingly, the only theory that I could form being that the trap belts had been thrown up through older sedimentary formations, such as the red conglomerates and marls I have mentioned; afterwards that the whole country was covered by an immense outburst of volcanic mud, which hardened into the "cantera," and subsequently the present system of hills and valleys has been formed by ages of disintegration and denudation.

This denudation is going on rapidly at the present day; most of the traps and other rocks break up readily by the action of the sun and wind, and large quantities are washed down by the heavy rains in the wet season, with the result that nearly all the hillsides are covered with a thick layer of *débris* of stone and soil, through which occasionally crop out any dykes of quartz or trap which may be locally harder than the rest.

This covering of the hillsides makes it difficult, in the majority of cases, to trace the course of mineral veins. They are generally more easily recognised on the tops of the hills, where they often stand up like walls for a considerable height above the ground. This is probably also the explanation of the fact that nearly all the old mines seem to have been discovered and worked downwards from the tops of the hills.

Between these beds of trap and porphyry, etc., and generally more or less conformable with them, run the mineral veins; sometimes reefs of solid white quartz, from 10 up to 50 feet in width; oftener much disintegrated and honeycombed, stained and mixed with oxide of iron, until in some cases almost black; sometimes much mixed with various coloured clays, and containing mica and pyrites, with gold in variable quantities, but generally invisible to the eye. There are also small and large veins of carbonate of lime, containing pyrites and gold in places, but more generally considered as matrices of silver ores. Most of the veins have a tendency, in depth, to change into or be accompanied by veins of solid iron pyrites, containing gold and often mixed with copper ores, while the outcrops are often accompanied by ferruginous gossans, and sometimes have caps of iron that has apparently been in a state of fusion.

A very general feature, common in all the world, but particularly marked in Mexico, is for the veins to contain their best ore in masses of no very great length, but continuing more or less vertically downwards through great depths, locally called "clavos." In such places the vein generally widens out, and the ore becomes soft and easily worked, sometimes so loose that it may be taken out with a shovel. Most commonly, too, the veins, particularly the large ones, consist of two or three, or more, streaks of ore, of varying richness, side by side, separated by layers of rock called, as with us, "caballos" (horses); and in cross-cutting this sometimes makes it exceedingly puzzling to know when the true side wall of the vein is reached.

In the district of El Oro (which takes its name from the general abundance of gold found there), the principal vein runs, at a short distance from the town, some six or seven miles in a N.W. direction, closely adjoining the junction line with the red conglomerate. Mines have been worked on it in various places since the early days of the Spaniards, some of which have produced very considerable riches, though none of them have been worked below the water level; but, like nearly all the old mines in the north of Mexico, at the time of the expulsion of the Spaniards, the owners hastily worked out the pillars and galleries before they fled, and the mines fell in. A few have been worked at different periods since, but when the water level was reached they were abandoned, and for many years till lately very little mining of any kind has been done, the country having been ravaged from time to time by the Apaché Indians, and otherwise impoverished.

This vein, in the upper parts, consists of quartz and oxides of iron holding "free milling" gold, but generally runs into pyrites towards the water level, and near Magistral contains, besides sulphides of copper, considerable quantities of sulphates of iron and copper ("magistral"), from which the place takes its name. These make the gold difficult of extraction by the ordinary native processes, and indeed by any process; moreover, the pyrites is hard to work and to grind. The old mines were accordingly only worked where the ore was soft and the gold "free."

The general character of all the ores of the district is "low grade," the average being probably about ½ oz. of gold to the ton; but I have been told by men who worked in some of the old mines that at times ores were obtained which produced as much as 1½ and even 2 ozs. per ton, and I have seen specimens even richer.

These "low grade" ores are a recognised general feature of all the mining districts east of the Sierra Madre, whether in gold or silver; but the lowness of grade is usually compensated by abundance and cheapness of production. To work ores of this class, however, requires considerable outlay of capital in machinery, so as to be able to deal with large quantities of material.

Eastward, from the line of this vein, the whole belt of country, nearly up to the plain, shows outcrops of numerous parallel veins of various sizes and characters, but very little work has ever been done on any of them. In the beds of almost all the watercourses descending from this tract, gold is to be found in considerable quantities, and on some of the streams there are "placer" grounds (alluvial deposits), which have been worked over in a primitive manner by the natives, the earth being washed by hand in "bateas" (a flat wooden bowl 2 feet to 2 feet 6 inches diameter) and they are well content if they can thus gain ½ to ¾ dollar (1s. 6d. to 2s. 3d.) per day.

The gold is generally in fine grains and scales, but coarse gold is often found, occasionally nuggets up to an ounce in weight, and once, some years ago, a large piece was found weighing several pounds. Unfortunately there is not sufficient water in the dry season to work the ground on any extensive scale; the abundant distribution of the gold however tends to show that some at least of the unworked veins must contain it, probably in payable quantities.

There is a tradition of a "lost mine" somewhere in this district; every mining district in Mexico, I suppose, has its tradition of a lost mine of fabulous richness, the story generally being that it was carefully sealed up at the time of the expulsion of the Spaniards, or during some revolution, or incursion of the Indians, and the owners having been killed or died, or the neighbourhood depopulated, the place was forgotten and grown over; many of these stories no doubt are myths, but sometimes they have a foundation of truth, and though, as a rule, it is hardly worth while spending time and money in searching for the mines, it is well to treasure up such information as can be obtained about them, accident and chance combinations of circumstances having sometimes resulted in the places being found.

In washing for gold a good deal of cinnabar (sulphide of mercury) is often found; two or three veins of this are already known, and one has been a good deal worked in former times. There are also known veins of silver and silver lead, while in the continuation of the range northward some good veins of carbonate of copper have been found, carrying a considerable percentage of silver and gold.

The foregoing description of the Magistral district might serve, with small variations of detail, for numerous other mineral districts of the north of Mexico; in almost every little range of mountainous country old pits and other traces of former mining are to be found, with mineral veins of all kinds, numbers of which have never been worked or prospected.

In Mexico all minerals (but not coal) belong to the Federal Government, but the right of working them may be obtained by any person, by a concession granted through the appointed authority, in accordance with the terms of the mining code.

Under this code, mining boards are established in the chief mining districts, consisting of a certain number of registered mine owners and mining officials, elected by all the rest, half the number being changed every year; these boards are entrusted by the mining department of the ministry of public works, with the management of all the mining business of the district and are responsible to the head department. In places where no mining board has been appointed the duties devolve on the political chief of the district.

To obtain a concession of mining rights for working a particular vein or mine it is necessary first to make a "denouncement" of the place, a formal notice to the district authority, laying claim to the property, setting forth the applicant's name and occupation, the situation of the mine or vein, the class of minerals to be worked, and concluding with an application for a grant of the necessary legal rights; this being received and registered secures the applicant's right for a period of four months, during which the authorities advertise the denouncement once in three successive weeks in the official journal of the State; meanwhile the applicant is required to sink a pit not less than 5 metres deep, and drive a level from it not less than 5 metres long on the course of the vein, which pit, whether afterwards utilised or not, becomes the official "pit of position" from which the measurements of the claim are set out; on informing the authority that these works are completed they send an engineer to examine and report on the character and position of the vein, etc., and afterwards to mark out the claim, and when this is done the chief of the authority with his secretary and some others, having given notice to any adjoining mine owners to be present, comes and examines the boundaries, and if no objection is raised by the other owners the claim is handed over to the applicant "in the name of the law." A document reciting the denouncement, advertisements, engineer's report, and a record of the whole proceedings, with a map of the claim attached, being duly registered, becomes the "title deed" to the property, which can be transferred or sold in the same manner as any other property; the cost of the whole transaction in fees, stamps, and other expenses, amounts to from 150 to 200 dollars (£22 10s. to £30), according to local circumstances.

A claim varies in dimensions, in accordance with sundry provisions of the code, by which a single person may acquire a length varying from 200 to 600 metres on the course of the vein by a width, governed by a scale based on the inclination of the vein, of from 100 up to 300 metres. A company, however (and according to Mexican law two persons may constitute a company), may obtain a length of 800 metres on the course of the vein. In the case of placers, the discoverer of a new-placer is entitled to a claim of 60 metres long by 20 metres wide, but for all other persons the claim is only 20 metres square.

The rights acquired under this law comprise the working of all minerals to an unlimited depth within the boundaries of the claim, and the occupation of any part of the surface for purposes of works, buildings, roads, and waterways, paying compensation to the owner for damage done, and continue for an indefinite time, as long as the requirements and regulations of the mining law are complied with, the most important requirement being that not less than six men are to be employed underground in some part of the claim for an aggregate period of 26 weeks in every year: making default in this, and in some other regulations as to proper ventilation and carrying on of the works, or in case of abandonment, the rights lapse, and the minerals revert to the Federal Government, and become again denounceable by any other parties. In a similar manner sites for reduction works (*Haciendas de beneficio*), and water rights for mill purposes or for drinking can be obtained by denouncement.

Coal, iron, and quicksilver pay no taxes whatever, but all other minerals are liable to a tax to the Government of the State in which the mine is situated, not exceeding 2 per cent. on the value of the metal raised without deduction for cost of working. Gold and silver are also subject to a mint-coinage tax, or an equivalent amount of export duty. Reduction works pay tax to the State on the same scale as other factories in the district.

The mining law as a whole is very complete and good, but like most laws has many loopholes and pitfalls. Speaking generally, I think it is too elaborate and not sufficiently elastic for the very variable conditions that are met with in so extensive a country, and consequently, in a primitive district such as that of El Oro, much has to depend on the discretion and goodwill of the Government officials. At the present moment the policy is to favour foreigners who are bringing capital into the country and opening up mining and other enterprises; but it might well be, in the case of a foreign owner making himself obnoxious to the authorities, that they could find means of driving him out of the country by enforcing strictly a number of harassing regulations which might make profitable working impossible. It is very advisable, therefore, in such places to keep on friendly terms with the authorities, and, as far as I saw in Mexico, with a little ordinary tact and judgment it is not difficult to do so.

The provision requiring six men to be kept working in order to maintain the title bears rather heavily on poor owners, and especially on foreign prospectors, as it hardly allows them sufficient time and opportunity for arranging with capitalists at home for mines that they have partially developed; but as far as I have seen, at any rate in the outlying districts, there is no class of "loafers" looking out for an opportunity of "jumping a claim," as is often the case in the United States; and the people generally seem to have an honourable feeling that a man, having taken up a claim and spent money on it, is entitled to hold his rights notwithstanding some default in meeting the requirements of the law, and the authorities are little likely to take action unless incited thereto by individuals.

The native methods of mining in this district have been and still are very crude and primitive, to our way of thinking, all the work being done by hand labour. The

usual procedure is to sink a shaft on the vein from some point on the outcrop near the top of the hill where it was first discovered, continuing this down, with irregular galleries branching off at intervals, and following the soft and richer parts of the vein, till water is reached, or till on account of the depth it no longer pays the cost of carrying the ore up the ladders. More rarely adits are driven in on the course of the vein, when it can be found lower down the hill; but I can only recall one instance in which the vein was opened by a cross-cut from the bottom of a valley, and that probably after workings had been commenced, and were getting deep, from the top of the hill.

The ladders consist of a round pole, 15 to 18 feet in length, with notches cut on one side. Up these the men carry the ore or rubbish on their backs in bags made of raw cowhide, supported by a broad strap passed round the forehead. In this manner they will carry up 100 to 150 lbs. at a time (sometimes more), and will so bring out about two tons per day from a depth of eight to ten ladders. The use of these ladders governs the construction of the shafts. When the sinking has reached the depth of one ladder, a set off is made a yard or two along the vein, and then another sinking started, so that ultimately the shaft becomes a number of steps of the depth of one ladder each. The galleries from these are small drivings following the soft parts of the vein, cut through irregularly from one to the other, with portions left here and there for support, resulting at last in cavities of great height being left, and sometimes, as I have seen in some of the old mines, 35 feet wide and 150 to 200 feet long. Generally some other opening to the surface is contrived for ventilation; but I have explored several old mines of considerable depth and extent which apparently had only one entrance, and yet I have noticed as a curious fact, and one difficult of explanation, that I have never found foul air in any of them. I have noticed another peculiarity, that even comparatively soft ground appears to stand better than with us, workings many years old remaining as perfect as when driven.

The tools used are an iron or steel bar about 5 feet long pointed at each end, or sometimes with a crescent shaped bit at one end, with which the ground is broken down, and a hoe with which the loose stuff is scraped into the hide bags; of late years the ordinary drills and hammers had also come into use, but many of the old works, even in hard ground, show no marks of the use of powder, the bar in the hands of a skilful workman is a very effective tool, and we met with very little success in trying to substitute picks, at least underground; on the other hand the men were not slow to appreciate the superiority of shovels and wheelbarrows, and adopted them readily.

When I first went the customary day's work consisted of drilling and firing 3 holes, 2 feet deep each, whether the ground were hard or soft, but with a little trouble we succeeded in establishing 8 hours' work as a standard day; at first, too, they had very little notion of doing piecework, but latterly we got all drivings and sinkings done by contract at so much a metre, the contractor paying for his powder and candles and carrying out the stuff. The explosive we used was "Giant" powder, an American manufacture of the dynamite class.

Water, where there was any, had to be carried up also on the back, in hides holding 18 to 20 gallons; this is heavy and expensive work, requiring a specially strong man to manage it.

The regular wages of the district for a miner is ¾ dollar (2s. 3d.) per day, and for a labourer ½ dollar (1s. 6d.), boys less, according to their age and skill. In working by contract we used to aim at arranging the prices so as to leave the miner about 1 dollar (3s.) per day each, clear of the expenses. We did not meet with any very hard ground. The price for driving levels 2 metres square, varying from about

12 to 22 dollars (36s. to 66s.) per metre, and at this a double shift of 4 miners and 2 labourers each, would drive from 4 to 7 or 8 metres per week. Wages are a good deal higher in some of the other districts.

The natives of the locality are generally poor miners, ignorant and lazy, but I found that with a little trouble and patience they could be taught, and as with workmen all over the world, by judicious "weeding" it was possible to get a fairly good set of men together. Some of those who had been away to other districts, where they had seen English or American miners at work, were much better and we had one or two strangers from other districts who were almost if not quite equal to average English or Americans. Timbering is an art in which they all seem deficient; on the other hand most of them can sharpen their own tools, which is an advantage where smiths are scarce and expensive.

It is customary to find all the tools for the workmen, these are served out to the different contractors or leading men of any gang on Monday morning, lists being kept, and all iron or steel weighed, and everything has to be returned to the store on Saturday night, any loss or undue waste being deducted from the wages.

The greater number of the men drink and gamble a great deal, and so contrive to spend nearly all their earnings on Saturday nights and Sundays, and often get deeply into debt, but they usually return to work on the Monday morning. As a rule they do not care to work on Sundays, and there are several feast-days and saints' days on which they keep holiday. Also most of the local men have patches of ground somewhere in the neighbourhood, on which they grow "Maiz" (Indian corn) for their own sustenance, and these always want to go off for a week or two at sowing time and harvest. One good trait in their character, and one which I believe is very general in all classes, is that when they cannot get work at their special business, they are not above turning their hand to any work, even as labourers. At least it is so amongst the steady ones; there are, of course, plenty of rascals who will do no work if they can help it, and who live by card-sharping and thieving, and generally speaking by their wits.

Where rich ore is being raised there is always a great deal of difficulty in preventing the men from stealing it, and in such cases it is common to strip and search them when leaving work. In one of the old mines it is said that the men used to be kept underground from one week's end to another, the richest ore being even washed in the workings. In another case the men found it worth their while to plaster their hair and themselves generally with the soft ore, and by washing themselves when they got home they were able to accumulate a considerable quantity of gold.

It is a generally recognised custom in most parts of the country for employers to keep a shop and pay a considerable part of the men's wages in goods, and in the wilder districts this becomes absolutely necessary; also it is very common to advance money or goods to the men, and most of them, as a rule, are in debt to their employers. This system is so well recognised that by Mexican law a man can be made to work out such a debt as a labourer; and in this manner most of the native ranch owners keep on the greater part of their workmen in a state of indebtedness at very low wages (9d. per day).

The people are generally about middle height and rather slightly built, but among the miners many are very muscular, active as cats, and capable of great endurance; it was very usual for a contractor to work himself through both shifts, and I have known them carry this on for many weeks in succession; a messenger sent on foot 100 or 150 miles will commonly do the distance and return in as little time as a man on horseback.

The ordinary dress of the miners and all the lower class is a calico shirt, loose calico drawers, and a calico or linen jacket, with a woollen blanket striped in

variegated colours—called a "zarapé"—thrown round the shoulders, a wide-brimmed straw hat and sandals of cowhide complete the costume; in the mine the drawers are rolled up to the fork, or quite as often replaced by a special bit of calico, and all the other clothing is discarded.

Some of them have very thrifty notions concerning their dress. I was much amused, when I first went out surveying, by a man whom I had told to cut down a particularly thorny bush proceeding to divest himself of all his garments before he started to work, explaining to me afterwards that his skin would mend itself but his clothes would not. Should it come on to rain a man takes his sandals off and rolls his drawers up as far as possible; with the varnish of American civilization that is gradually finding its way south from the frontier trousers are becoming more common, but I always looked with a certain amount of suspicion on a miner who had taken to wear "pants."

The native method of extracting the gold is as follows:—The ore is first ground in a rude mill, called a "tahona," or in some parts an "arrastre," which consists of a circle of flat stones some 6 to 8 feet in diameter, set up edgeways in the ground, the enclosed space being paved with other stones laid flat, about a foot deep below the top edge of the outer circle, a strong post is fixed in the centre, shaped into a pivot at the top, on which a long cross-bar revolves, a donkey being attached to the outer end, from this cross-bar two large stones with flat side downwards are hung, or rather dragged by hide ropes, one on each side of the centre post, and so arranged that between them in revolving they cover the whole of the space between the post and the sides, altogether very similar to an ordinary mortar pan, the two large stones taking the place of the rollers.

Into this from 300 to 600 lbs. of ore is charged and ground with water till it is reduced to a fine pulp, requiring from eight to ten hours or more according to the hardness of the ore, the mill is then filled up with water dashed in, and after settling for a few minutes the water baled out again, this washing being repeated several times, the clay and fine light particles have been removed leaving the heavy sand clean at the bottom, this residue is then carefully scraped out and laid on one side.

The process is repeated till a considerable heap has been collected, which, if the ore contains much pyrites, is left for several days to "sweat," during which the pyrites to a great extent decomposes, ultimately the heap is all washed little by little in a "batea" with a small quantity of quicksilver which catches up the particles of gold, the quicksilver is then squeezed through a cloth folded several times leaving a ball of amalgam in the cloth, and this being heated in a fire the quicksilver is driven off and the gold remains.

In this manner they get out about 30 per cent. of the assay value of the ore, and the gold obtained is sold to the shopkeepers at about 17 dollars (51s.) per ounce avoirdupois, these latter making a good profit out of it, since the gold being generally about 900 fine an avoirdupois ounce is worth about 22½ dollars at the mint, less the Coinage Tax.

As a grinder this "tahona" is very efficient, and in that respect I question if any of the modern grinding pans, many of which are based on the same principle, surpass it, but the action is slow and not continuous; it is used in a much improved form in the reduction works in the more advanced mining districts, being made larger and driven by two mules or horses, by water-power or even by steam, and I think by a little contrivance they might be made to feed and discharge continuously, and by combining some of the modern systems of amalgamation the great loss which now occurs might be avoided or much reduced. This loss I consider takes place in the washing in the mill, for necessarily much of the gold must be ground into very fine particles, which are carried away in the clay slimes.

With all its faults, however, the "tahona" is not to be hastily despised and condemned. It is cheaply constructed and cheaply worked and kept in repair, and can be utilised in any situation where there is sufficient water for the washing and where a little bit of level ground can be got, while it can be erected in places to which it would be impossible to convey modern machinery.

I hold a very strong opinion, that in any country the native processes, however crude, are entitled to a high degree of respect. They are the outcome of hundreds of years of experience, and generally contain principles that are suited to the conditions under which they have to be used; and it behoves a stranger to be very cautious and to give a great amount of careful consideration to all the surrounding circumstances before deciding on the introduction of expensive modern machinery and elaborate processes, however successful they may have proved in other places.

For want of this careful consideration there have been many failures in Mexico in what would have otherwise been promising ventures. Machinery has been erected, and being found to be unsuitable had to be replaced by other kinds, and I am reliably informed that at the present moment there are numberless pieces of fine new machinery lying about abandoned by the roadside in different places in the mountains, which could not be got to their destination, or which it was found would have been useless for their purpose if they could have been carried forward.

A case somewhat in point came under my own notice. An American company, who for five years have held mines adjoining ours in the Magistral district, being engaged when I left in building their *third* mill, the two former, each of a distinctly different type and process, having failed to give good results. Their mines contain a great deal of the heavy pyrites ores I have mentioned, and there is yet room to doubt whether their third trial will prove successful or no.

Moreover, I consider that it is unwise in such a country to strain after the uttermost possible percentage of gold in the first instance, by means of modern refinements in machinery and processes. In every particular case there must be a point, only to be discovered by experience, beyond which the difficulties and cost of working such appliances outweigh the value of the gold saved by them.

Taking advantage of our American neighbour's experience we erected one section of a mill of a tolerably simple type as a trial. It was built on a steep bank alongside the Magistral "arroyo," which allowed a total fall of about 40 feet. The ore was brought in at the top and emptied from the bags, in which it had been carried on donkeys, on to a sloping grid like a colliery screen. The fine part went through into a large "bin;" the rough stones slid down on to a platform, where they were put through a stone-breaker delivering into the same bin below.

From the bin the crushed ore travelled down a shoot to the hopper of an automatic feeder, which delivered it in regular quantities into the grinding mill, a regulated quantity of water being fed in at the same time.

The "grinder" was a 5 feet diameter "Huntington" mill, which consists of a fixed circular iron pan about 2 feet deep, with a spindle up through the centre, driven by gearing underneath. The head of the spindle carries a cross, from the ends of the arms of which hang four heavy rollers faced with steel rings: these revolve against the inner face of a large steel ring fixed in the bottom of the pan, and when in motion are pressed outwards against it by centrifugal force. Four scrapers between the rollers throw the ore and water outwards against the face of the large ring, where it is ground between the ring and the rollers The front half of the pan has an opening fitted with a screen of suitable mesh, through which the water carries any particles that are ground fine enough. A well in one side of the bottom filled with quicksilver allows small portions to circulate with the ore and thus collects a considerable portion of the gold.

The sand and water, after passing through the screen, may be subjected to any particular process of amalgamation. In our case it was passed over two lengths of amalgamated copper plates, each 8 feet long by 4 feet wide, placed at such a slope that the water current was just sufficient to keep the sand travelling; and beyond these it ran a distance of about 100 feet to the "arroyo" in a wooden "sluice-box" with cross-bars or "riffles" on the bottom at intervals.

The particles of gold that had escaped the quicksilver in the mill were caught by the amalgam on the plates or by quicksilver placed in the "riffles." The amalgam was scraped from the plates two or three times a day, the quicksilver in the well tapped daily and squeezed through a cloth or a piece of buckskin, and when thus a sufficient quantity of amalgam had been collected it was put into an iron retort and the quicksilver distilled off. The gold remaining in the retort in a spongy mass was then smelted and refined in a crucible in the ordinary way, and run into small ingots.

Once a week a general clean up of all the sluice-boxes and other parts is made, and once in, say, every three months the whole mill would be taken to pieces, when generally a considerable quantity of amalgam would be collected from the joints, etc.

This system saved about 70 per cent. of the assay value of the "free-milling" ores, but gave very poor results with the heavy pyrites ores. I think the amalgamating power might have been increased by a greater length of plate surface, possibly also by a combination of mercury troughs and by a greater length of sluice-boxes.

The capacity of the above mill was about 20 tons of ore of medium hardness in twenty-four hours, with a 50 mesh screen, and used about 15,000 gallons of water per day. The "Huntington" mill is a good pulveriser, but I doubt whether it would crush specially hard and tough quartz so well as Stamp's. It is fairly simple, does not easily get out of order, and the wearing parts, that is, the steel rings, are readily exchanged and replaced when worn out. A 5 feet diameter mill requires 6 to 8 horse-power to drive it, and costs 1,500 dollars American (£300) at the works.

Three men are required to work such an arrangement: one to attend to the engine and boiler; one to feed the crusher; and one, who should be an English or American mechanic, to watch the mill and generally superintend the place, but one such man could well look after two or three mills. At night the crusher would not be in use, and one superintendent and the stoker are all that are required. We found that we could raise the ore, bring it a mile on donkeys, and put it through the mill at a cost of 4 dollars (12s.) per ton.

Notwithstanding that we had gone into the matter very closely ourselves, and that the whole plant ("outfit," as the Americans call it) had been designed and arranged by an eminent firm of American engineers, who have had great experience in such machinery, there were several points in which it did not come up to the requirements.

For instance, the engine and boiler were calculated to drive the whole works with two mills, and the engine, a nominal 30 horse-power, would no doubt have done it, but the boiler, a tubular locomotive type, would not keep steam for one mill with the fuel we had to use; possibly it was calculated for burning coal, but as we had only wood fuel of local oak and a kind of juniper, and that somewhat green, it failed ignominiously, and gave us a lot of trouble; then the crusher, which did very well with dry crisp quartz, could not get through its quantity if the quartz or other rock was wet and mixed with clay and earth, and required a second man to assist in feeding and forcing the stuff through.

The pump which raised the water from the stream to the tank supplying the mill could only be run when there was plenty of steam in the boiler, and accordingly was not large enough to supply the quantity in the intervals, when we were able to work

it, the feed pump too, a plunger attached to the engine would only keep up the supply to the boiler by running full time, and as we often had to stop to get up steam the boiler got frequently short of water, and when we borrowed and fixed an injector instead, of a rather old-fashioned pattern, and had to work with dirty water in the wet season——I am afraid to describe the scenes that frequently took place.

I only mention these troubles of ours for the purpose of showing how necessary it is, when arranging machinery for use in rough and out-of-the-way countries, to allow a much greater margin for contingencies than we are accustomed to do at home; and not only so, but to adopt the simplest possible class that will do the work, such as can be handled by native labour and can be most easily repaired, for in case of a breakdown of anything it is not possible to telegraph, say, to Birmingham, for a duplicate part and get it down by train next day; if we required a new piece for any of our machinery, even so simple a thing as a pair of jaw-plates for the crusher, we had to write to Chicago for it and were very lucky if we got it in three months.

Ample supply of clean water is very essential for such works, and in a mountainous and semi-tropical country it should not be taken from a river or stream; we made the mistake of doing so by means of a well near the bank of the "arroyo" connected to the bed of the stream by a drift filled up with gravel; but when the wet season came on, the mud brought down by the floods covered the river bed and prevented the water getting through, and when the mud was cleared away the water came through dirty, and gave us a deal of trouble both with the pump and the boiler.

Transport in a wild country is also a consideration of great importance. From time immemorial the working of pack animals has been one of the institutions of Mexico, and I suppose the natives are hardly to be surpassed in any part of the world. One of the earliest things a boy learns is to load up a pack and drive a donkey, and almost every man, except the very poorest, owns two or three or more. Those who make a business of carrying goods often own twenty or thirty animals, and it is calculated that if a donkey earns a ½ dollar (9d.) per day he pays expenses. A man by himself can usually drive up to ten or a dozen, and, with the assistance of a lad, perhaps twenty. He loads them up and starts out for a journey of say 150 or 200 miles, 200 lbs. being the regular load. At nightfall he looks out for a suitable spot, a little off the road, with grass, water, and firewood; unloads the donkeys, laying their packs in a row on the ground, turns the animals loose into the scrub to pick up what they can, lights a fire, cooks and eats his supper, rolls himself in his "zarapé," and goes to sleep on the ground, taking turns with the lad during the night to give a look round to see that the donkeys have not strayed too far. Before daylight, while the lad collects the beasts, he makes and eats some breakfast, then loads up the packs, and starts off as before. In this way they get over 20 to 25 miles a day, and the freight will run to about £3 per ton per 100 miles (ton of 2,000 lbs.).

Where there are sufficiently good roads for wheeled vehicles to travel goods can be carried in wagons at something like 30s. per ton per 100 miles. When I was in Parral, last November, silver ore was being carried in this manner to Jimenez, about 75 miles, at 16s. 10d. per ton; the wagons are usually of American build, and drawn by a team of eight to twelve mules.

The Mexican mule is much smaller and hardier than those used in the United States. Last summer, a well-known American teamster, from the Western States, brought a large train of wagons and mules to carry silver ore from some mines to the railway, in a district some distance to S.E. of El Oro, but could not compete

with the natives. He lost some 8,000 or 9,000 dollars in a few months, many of his mules dying. He ultimately had to break up his teams, sent his American drivers and the remainder of the mules home, engaged native drivers and mules, and I believe has since done well.

Horses are not much used for draught purposes but are much more common for riding now than mules. A fair useful saddle horse can be bought from a ranch at from 30 to 50 dollars (£4 10s. to £7 10s.), but a good saddle mule will cost 70 to 80 dollars and upwards (£10 10s. to £12); a saddle and bridle costs 25 to 30 dollars (£3 15s. to £4 10s.).

Materials and tools for mining purposes are mostly of foreign manufacture, and consequently expensive. For instance, drill steel in bars, 9d. per lb.; small bar iron, 6d. per lb.; hammers, 1s. 1½d. per lb.; miners' picks, 6s. 9d. each; short shovels with handle, 6s. 4½d. each; axes, 6s. each; pick and axe handles (hickory), 2s. 5d. each; "giant" powder, 1s. 1d. per lb.; black powder, 6d. per lb. On the other hand things of native production are not so bad. Pine poles, 22 feet long, 10 inches diameter at the butt, could be got at 3s. each; 3 inch planks, 8 feet 3 inches long, 14 inches wide, 2s. 7½d. each; but it was necessary to agree for and order these two or three months beforehand, and generally to advance half the money. Larger timber became much more expensive, and was very difficult to get at all. An American cord of firewood (128 cubic feet, measured in the stack, and weighing about 3,300 lbs.) cost 8s. 2d.

"Adobés" (sun-dried bricks 2 feet by 12 inches by 5 inches), for building, made on the ground cost 22s. 6d. to 24s. per 1,000. A good mason with his helper and a gang of labourers and boys, making the mud mortar and carrying the "adobés," can lay 600 to 700 per day, the cost of the whole gang being 21s. per day. Some masons in a straight wall can lay 1,000 in a day.

Provisions are very variable in different districts, both in abundance and price; with us, meat, vegetables and milk, were difficult to get in the dry season. The staple food of the natives at that time is dried meat flavoured with "Chile" with Indian corn cakes and beans. We could generally get also fowls and eggs. A bullock cost 40s. to 50s.; a sheep, 6s. to 8s.; fowls, 9d. to 1s. each; Indian corn, 6s. to 9s. per "fanega" (about 100 lbs.).

Notwithstanding the many drawbacks of which I have spoken, I have come to the conclusion that Mexico is a country of much future promise, presenting great openings, especially for mining speculators, it is rich in all kinds of mineral wealth, and though some of the richest districts are at present very difficult of access, the opening up of the country by the construction of railways, which is going on rapidly, will in a few years bring most of them within reach; even now there are plenty of places where good money may be made in mining with ordinary care and attention to the surrounding local circumstances. The authorities and the people are friendly to foreigners, especially Englishmen, so long as they behave themselves. The laws are good, though at present partly through ignorance and sometimes through corruption they are often badly administered, this will no doubt be improved by the spread of education, which is being pressed upon the people by means of schools in every town and village. The party of progress and order which for some years past has held the reins of power appears likely to remain in the ascendent, and the era of revolutions seems to be passed. The Government is alive to the importance of encouraging industrial enterprise of all sorts, and is offering many facilities to foreigners who engage in them. The general trade and financial position of the country are improving, brigandage has been practically suppressed, and life and property are generally as secure as in most other foreign countries.

Added to this, the magnificence of the scenery in the mountainous districts, the delightful climate of the table-lands of the interior, and the civility and hospitality of the people which pervade all classes, tend to make life enjoyable, and though there are many inconveniences to put up with, and an absence of comforts which many of us at home have been accustomed to consider essential. I for my part shall always look back on my short sojourn in the country with feelings of pleasure and regret.

At the conclusion of Mr. Glennie's paper, some mineral specimens which he had brought with him from Mexico, and had presented to the Institute, were placed upon the table for inspection.

Mr. TREGLOWN asked what direction the metalliferous veins took, how wide they were, and, further, whether in the part spoken of by Mr. Glennie—35 feet wide—it was necessary to support them ?

Mr. GLENNIE—The veins run N.W. and S.E. mostly ; in fact, they follow something like the direction of the range of mountains in which they are situated. There are veins running in other directions, and sometimes in the same district there will be apparently one system of veins which will run more or less parallel and another system which run entirely different, one sometimes producing gold and the other silver. They are also of every width and thickness, many even exceeding 30 feet in thickness. Generally they require very little support, and there are large saloons in some of the old mines that were worked in the time of the Spaniards still standing without any support whatever : support where required is generally given by leaving parts of the vein unworked for pillars.

Mr. TREGLOWN—Do you find water at the bottom ?

Mr. GLENNIE—We only just touched on the water. In this district nothing has been worked below the water level. Near the water level the veins seem to change into the pyrites, which almost all carries gold more or less, but it is a very difficult ore to work.

Mr. TREGLOWN—Is there a system of calcining ?

Mr. GLENNIE—No ; it has been tried in various ways. An American company tried a system of roasting to drive off the sulphur, but in doing so it seems probable that the particles of gold are coated with the iron oxide or sulphur which prevents their amalgamating. The question of the loss of gold in the amalgamation process was one which was open to be dealt with, and presented an opportunity of making a fortune.

Mr. COLLIS, in proposing a vote of thanks to Mr. Glennie, said that, although many of the members had a very partial knowledge of metalliferous mining, especially when that mining took the form of searching for the more valuable metals, still the subject of the paper had been one of general interest and also a matter of instruction in the art and process of procuring gold. He moved—"That our best thanks be given to Mr. Glennie for his very able and interesting paper."

Mr. FARNWORTH seconded the resolution.

The CHAIRMAN, in supporting the resolution, said that it would be agreed that the paper showed that Mr. Glennie was not only able to take a comprehensive view of the subject, but that he was also a master of detail.

The resolution was carried unanimously.

Mr. GLENNIE, in acknowledging it, said he was exceedingly obliged to the members for the manner in which they had received the paper. A great deal might be done in mining in Mexico. It was carried on there by very rough and ready methods, but such as they were the results were good. The cost of working by such methods was not great. At the present time some of the best work that was being done in Mexico was by people who had found some small mines of particularly rich silver lead veins turning out only a few tons a day. They convey it to the railway, and there sell it to the agents of the United States Smelting Companies, who are ready to purchase it. Little or no capital is required. The United States Government had lately put a tariff on lead, and it could not be sent so cheaply to the States now as it could six months ago. The difference meant that the vein should carry 60 or 70 ounces to the ton instead of 50, in order to allow for this tariff.

PROCEEDINGS.

FEDERATED INSTITUTION OF MINING ENGINEERS.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD AT THE INSTITUTE ROOM, BARNSLEY, ON WEDNESDAY, 11TH DECEMBER, 1889.

MR. C. E. RHODES, PRESIDENT, IN THE CHAIR.

In the temporary absence of the President, Mr. John Gerrard was, on the motion of Mr. COBBOLD, seconded by Mr. LUPTON, called to the chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated:—

MEMBERS—

Mr. John James Reynolds, Mining Engineer, Swinton, near Manchester.
Mr. William Rawton, Mining Engineer, Longsight, Manchester.
Mr. John D. Kendrick, Mining Engineer, Manchester.

Mr. T. W. H. MITCHELL—The first paper is by Mr. A. Bertram, who is not a member of the Institute. He has contributed a paper which, by the rules of the Institute, may be read; and, with the permission of the Chairman, Mr. Bertram may take part in the discussion.

Mr. Mitchell then read Mr. Bertram's paper on "Overwinding and its Prevention":—

ON OVERWINDING AND ITS PREVENTION.

By A. Bertram.

During the year 1888 it was estimated that about 170,000,000 tons of coal were raised, giving employment to half a million miners. During that time only one life was lost by overwinding, which speaks volumes for the care exercised by the men in charge of the engines. We do not know, however, how many cases of overwinding did occur which involved loss of time and injury to property, as there are no records to show, and colliery proprietors and managers are, as a rule, very reticent on these subjects. When pits were shallow, and the output from each was small, there was not the same danger from this source as there is now. With increased depths, greater speeds, loads, and output, the danger becomes increased; and this may be seen in the number of inventions which have been introduced during the last 30 years to prevent, or to lessen the effect of, overwinding. Time was when there was neither safety cages, detaching hooks, or other appliance of that class. Gradually, however, safety cages, detaching hooks, and stopping gears were introduced, and now there are not many collieries of magnitude without one or other of these being attached. One has only to watch a pair of powerful engines make a winding—watch them acquire an accelerating velocity, then gradually stop within a few inches each time—to come to the conclusion that such safety arrangements are an absolute necessity. A quarter of a stroke too far—nay, with some engines the length of the slide block only—is sufficient to cause an overwind.

It is not the writer's intention to go into an elaborate description of the different safety arrangements at present applied, but briefly to draw attention to their advantages and disadvantages.

Safety Cages have been before the mining world a long time. They are extensively used on the Continent, and to some extent in England. They are intended to prevent the cage falling back in case the rope breaks or in case an overwind occurs. They do not safeguard the descending cage in a case of overwinding. They do not seem to have found favour in the eyes of engineers, to judge from the fact that pits, fitted throughout with them when first introduced, are now found to be without them. It may be that they were too intricate to withstand the wet and dirt and dust of a shaft, or that they came into action at times when not wanted. With wire guide rods, now so prevalent, engineers hesitate to apply tackle to cages, which, if brought into action, might bring the rods out of the headgear.

Safety Hooks or *Detaching Hooks* are intended to sever the connection between the rope and the cage in case the latter is drawn too far into the headgear. They are of various kinds, some being self-suspending and others simply releasing hooks, depending on catches fixed in the headgear to support the cage after release takes place. Overwinding has actually taken place before they come into action, and they, like safety hooks, do not afford any protection to the descending cage. They have proved of great value since their introduction, and have undoubtedly been the means of saving lives and property, and may be relied on to act efficiently with slow or relatively slow overwinds. With fast overwinds, however, they have been known to fail through the shearing plate or cylinder being torn away or bursting, or through the plates forming the hook failing and allowing the hook to back down

through the ring or cylinder. When a safety hook travelling at say 40 miles an hour enters a cylinder and detachment takes place, the cage, still partaking of its acquired velocity, continues to rise till its energy is expended, or till it comes in contact with the headgear caps; then it drops back with a jerk, maybe causing the hook to fail or the chains to snap; the capping flies out over the pulley and injures the engine house roof, and if the engines are not then stopped the descending rope will be reversed on the drum and further damage done to the plant and buildings. In the meantime the descending cage has been heavily bumped on the bottom, in some cases breaking through the scaffolding over the sump or dib-hole. A fast overwind, even when the hook acts all right, is always an expensive one.

Stopping Gears are numerous, and may be divided into two classes, the first of which shuts steam off and applies the brakes directly the cage has been drawn too high into the headgear; the second contemplates automatic winding.

The first class is on much the same lines as safety hooks, and beyond the fact that they initiate the arresting mechanism, and so prevent further damage, they are not, to the writer's mind, to be preferred to safety hooks. Like safety hooks and safety cages, they do not safeguard the descending cage. They are useful in preventing the engines from being started the wrong way, or in stopping the engines from "creeping," but one might as well expect a locomotive travelling at 40 miles an hour to be stopped in its own length as expect the cage when travelling at that speed to be stopped before detachment takes place. If the drum could by any human means be stopped, the cage would continue to rise till it came in contact with the headgear caps or until its energy was expended. Such an arrangement takes time, however little, in which to act, and in the meantime the cage keeps travelling onwards, and as a rule there is not more than 15 feet clearance in most headgears.

The second class of stopping gears do safeguard the descending cage. They are designed to shut off the steam only, or to apply the brakes also, when the cages are passing a certain defined point in the pit if this has not been already done by the engineman. This is done every winding, whether the cages are travelling fast or slow, and independent of the load or steam pressure. If the mechanism is arranged for loaded cages and pressure low, it must be wrong for unloaded cages and pressure up; or if in time for unloaded cages and pressure up, it would be too soon for a low pressure and loaded cage. If, also, a load was being sent down, it might close the valve and apply the brake if the valve was open, but would do nothing to arrest the engines if the valve was closed and the cage travelling too fast. Again, it might come into action when pit work was being done, or when the daily inspection of the pit was being made, and would tend to interfere with that discretion and latitude which must be allowed the engineman with the ever-varying loads, pressure, and speed.

I have now the pleasure of drawing your attention to an apparatus (see Plate I.) which I have invented to overcome some of the objections raised in the preceding remarks, and which I have named "The Visor."

Fig. 1 is an elevation of the principal portion of the apparatus.

Fig. 2. is a plan of same.

Fig. 3 is a section on line X X. (Fig. 2.)

Fig. 4 is a central section (at right angles) to Fig. 3.

A is the framework of the apparatus, which is secured in any convenient position. B is a rope, chain, or rod connected with the lever or spindle of the throttle valve, and with the steam or foot brake or both through the medium of suitable mechanism, which has a constant tendency to close the throttle valve and put on the brake. The said mechanism can, however, only become operative when the connection between

the rope B and the framework A is severed. The rope B attached to a sliding catch bar B^1 which is held in position on the framework by a pivoted catch or pawl C having its free end c resting in a notch in or against a shoulder on the bar. Or the catch may be simply pressed upon the bar by a counterweight or spring. The bar B^1 is released as hereinafter described whenever the speed of the cage (that is, of the engine governor or governors), at a given point or points in its travel, reaches or exceeds a given amount.

D is a revolving shaft, which is connected on the one hand with the engine or winding drum, and on the other hand by means of suitable gearing such as D^1, D^2, D^3, D^4 with a revolving shaft E carrying one or more beaked cams E^1 according to the number of governors employed in the apparatus, that shown in the drawings being provided with two, set for different speeds. The gearing connecting the shaft E with the winding engine or drum is so proportioned that the beaked cams make one revolution during the travel of the cage between two given points. The governors are also preferably driven by the shaft D by gearing d, d^1, d^2, d^3, Fig. 1.

On each side of the beaked cam is a tappet or hook F which is adapted to be engaged by one of the beaks when the governors are going at or beyond a given speed, the particular hook engaged depending upon the direction of rotation of the shaft E, that is upon the direction in which the cage is travelling. The hooks are preferably spring pivoted or counterweighted as shown, and each hook is carried by an arm F^1, the said arms being kept apart by springs, or by their own weight or otherwise. The arms F^1 are pivoted to crossheads F^2 forming part of or connected with a rod or bar F^3, Fig. 4, which is connected by a link F^4, or its equivalent, with the pawl C aforesaid. The bar F^3 may be counterweighted if desirable.

G, G, Fig. 3, are two rotatable spindles, each carrying a bell crank lever G^1, G^1. One arm of each lever engages the arms F^1 by means of the slots g, and the other lever arms are connected loosely at their free ends, so that the movement of one lever is imparted to the other. One of the spindles G carries an arm G^2, which is connected by means of a link G^3 with the counterweighted governor lever H. By this mechanism the arms are moved inward simultaneously as the speed of the governor increases.

Instead of the bell crank levers G^1, their mechanical equivalent might be substituted in the form of two cams or eccentrics, each connected by a link with the spindle or lever of the governor, and bearing upon the outer edges of the arms in such a manner that when rotated by the links as the speed of the governor increased they would force the arms towards each other simultaneously.

The mode of action of the above portion of the apparatus is as follows:—When the engine is going below its given speed the hooks F are not moved into the path of the beaked cams, but when the engine attains or exceeds a certain given speed the governor or governors rise, and the eccentrics or levers G^1 are turned upon their pivots, and the hooks are placed in the path of the beaks of the cams E. One of the beaked cams will now catch a hook F and raise it, provided the cams are in the position corresponding to the aforesaid given point or points in the travel of the cage. The hooks being raised, the arms F, crossheads F^2, and bar F^3 are raised also, and the pawl C is disengaged from the catch bar B^1, and the latter and the rope B released so as to apply the brake and shut off steam as before set forth. If, however, the governor be slackened in speed before the beaked cam arrives at one of the aforesaid positions the hooks are drawn back, and the cam passes them without coming in contact with them.

J is a rope, chain, or rod, which is connected at one end with one or more tappets or levers projecting in the path of the cage, or other moving part having the same

relative motion as the cage. The other end is attached to a sliding catch bar J^1 having an inclined surface j which rests below a pin or projection c^1 on the end of the catch or pawl C, so that the latter is disengaged from the catch bar B^1 when the bar J is drawn outwards. When the cage or its equivalent strikes one of these tappets the rope J is pulled, the catch or pawl C released, and the stop valve closed and brake applied independently of the speed at which the cage is going. This latter arrangement may be employed either in conjunction with or independently of the beaked cam and governors and the mechanism connected therewith.

From this description it will be noticed that so long as the engineman keeps his engines under proper control, and does not come too fast when nearing the top, "The Visor" does not interfere; but should he keep steam on too long, and the speed be kept too high when it should be lowered, then "The Visor" steps in and shuts steam off and applies the brakes. The engineman, to put it another way, starts the cages and applies full steam; in due course he shuts it off, and the engines slacken speed and come to rest. If he had not shut steam off at, say, the 5th stroke from the top, "The Visor," recording at, say, the 3rd stroke from the top that the engines were going faster than they should go at that particular point, immediately steps in and arrests the engines by shutting off steam and applying the brakes. The speed of the engines is again reviewed by "The Visor" within a stroke or so from the top, when the speed should necessarily be still lower than at the 3rd stroke, and with the same results.

As a still greater security, an arrangement has been added in the headgear whereby, in the event of the engines being started the wrong way, or of the engines "creeping," or a slow overwind taking place, the stopping mechanism attached to "The Visor" is actuated and the brakes applied. This takes place independent of velocity. "The Visor" depends for its action on velocity, and, while it will not stop a slow overwind, yet it will certainly stop a fast one. "The Visor" merely liberates the arresting mechanism to do its work, and on the power of that mechanism depends how soon the engines will be arrested. It may be said that to apply a powerful brake to a quickly revolving drum would be dangerous; but if an engineman became aware that he was about to overwind, would anyone blame him for using all the appliances in his power to prevent its taking place? "The Visor" only does what he would do.

It does not interfere with the engineman in any way, nor with the output. The engines may go as fast as they will up to a certain point; after that it takes notice, and is ready to interfere if required, but not otherwise.

One of these machines has been at work constantly since June, 1888, and has been repeatedly tested with satisfactory results. There is nothing about it that with ordinary care and attention is likely to get out of order, and it will last for years without repairs.

It safeguards both ascending and descending cages, and will reduce the speed of the cages and render the action of safety hooks tolerably certain if the brakes are not of sufficient power to stop the engines entirely.

It can be readily and cheaply applied to all classes of winding engines, the cost depending in some measure on what is necessary to be supplied to drive the machine and actuate the levers of steam valve and brakes.

It can be made to shut off the steam, apply the steam brake, apply the foot brake, un-notch reversing lever and bring it to mid-gear, open relief valves of cylinders, close valve in exhaust pipes, or all of these if required.

With "The Visor" applied to prevent a fast overwind, the arrangement in headgear to prevent the engines being started the wrong way, and good detaching hooks, disastrous overwinding seems an impossibility.

To illustrate Mr A. Bertram's p

FIG. 1.

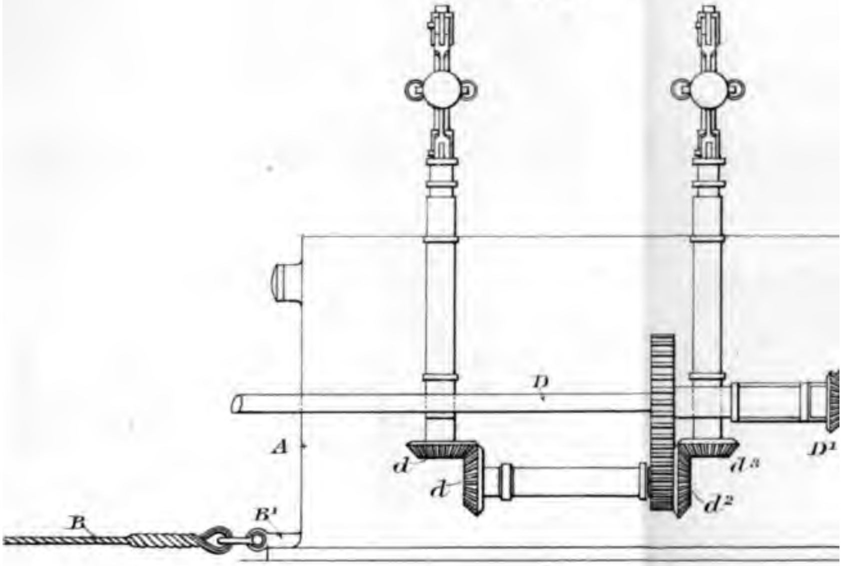
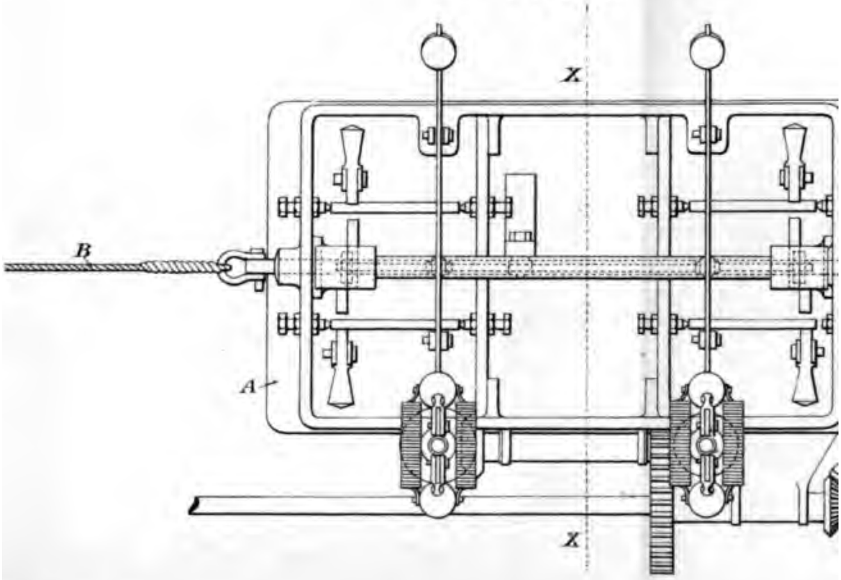


FIG. 2.



If thought desirable, a cord can be attached whereby the banksman and the hooker-on can, in case of emergency, stop the engines from the pit bank or pit bottom, as the case may be. Such an arrangement would be useful at times, as, for instance, if any one was to fall into the path of the descending cage when it was nearing the bottom, or in the event of something going wrong in the shaft. It would, of course, have to be properly protected from improper use.

Mr. Bertram also attended with a model of his invention, which he exhibited and explained to the members.

Mr. A. LUPTON—If it is in order, I shall propose a vote of thanks to Mr. Bertram for his paper, for his illustrations, and for attending here with the model; and also, that the paper be printed.

Mr. MARSHALL seconded the motion, which was carried.

Mr. C. H. COBBOLD read the following paper on "A Patent Apparatus, Indicator, and Valves for the Automatic Prevention of Overwinding at Mines":—

A PATENT APPARATUS, INDICATOR, AND VALVES FOR THE AUTOMATIC PREVENTION OF OVERWINDING AT MINES.

BY C. H. COBBOLD.

Cases of overwinding, with more or less serious results, are unfortunately too common at our collieries, and are too fresh in our minds to make it necessary to name any particular cases.

We are provided with numerous safeguards which attempt to prevent fatal results from overwinding cases, whether they originate from carelessness or forgetfulness on the part of the engine tenter, or arise from some defect in the engine which prevents the engineman from turning off the steam at the proper time; but, notwithstanding these safeguards, fatal results are in our recollection, and even in cases where the disengaging hook has come into operation and saved life, the effect upon the nerves of the men finding themselves suddenly stopped and dropped the length of the cage chains and suspended in a way they cannot but mistrust is serious; and the delay in reforming the connection between the cage chains and the rope—if the engineman has been fortunate enough to stop his engine and prevent breakage to the machinery or engine house—and the subsequent careful examination of all the parts affected, is a consideration out of a short working day..

The necessity for devising some certain method of obviating any possibility of overwinding or mishap from forgetfulness or carelessness, and avoiding the delay to the working or chance of injuring the men or the machinery, has for some time past exercised the minds of the writer and Mr. W. Wood—a practical engine tenter. The result has been the design now brought before your notice after having been protected by letters patent.

In the apparatus about to be described, and which I hope will commend itself to your notice, nothing is left for the engineman to do. If he works his engine in the proper way, the apparatus lies dormant; but if he exceeds by a foot per second the speed at which he is set to bring the cage to the pit top, or raises the cage a degree higher than he is set to raise it, the apparatus comes by itself into action, and his engine cannot execute another stroke until it is perfectly safe for it to do so. The great utility of this one fact will readily be appreciated when we recall cases where the engine has continued to revolve after the disengaging hook has come into action with one cage, and the second cage has been wound up and suspended in the head-gear, and the engine has only been stopped by steam being turned off at the boilers, it not being safe to enter the engine house where the two loose ends of the ropes are revolving and breaking the roof and bringing down the building.

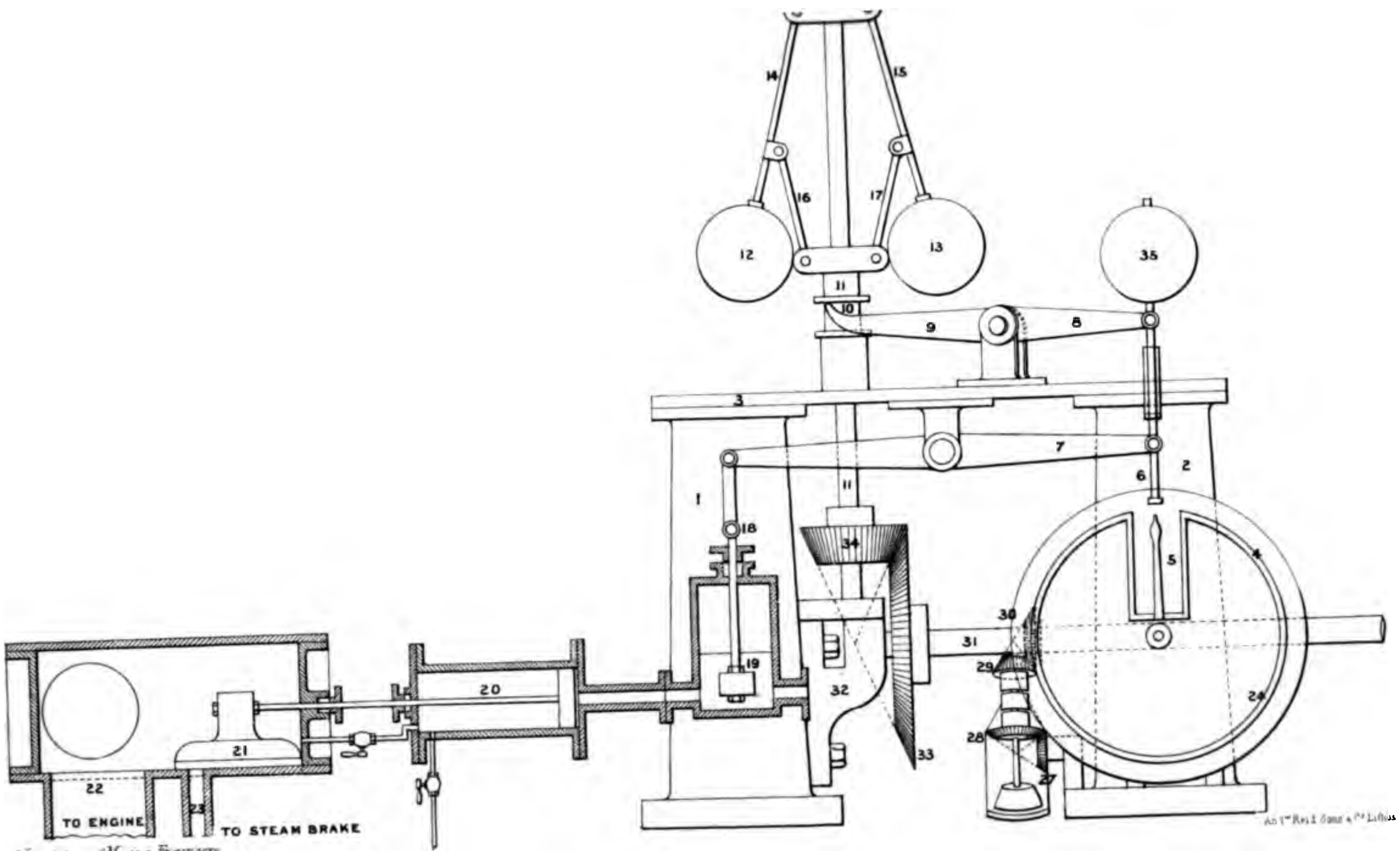
The description of the apparatus and its working is as follows (see Plates I., II., and III.):—

Two metal pillars (1, 2) are fixed on a bed or frame in the engine house, and are connected at the top by a girder (3). On one pillar (2) is pivoted on a stud or bracket a flanged disc (4), having a depression (5) in one side of the flange. This flange supports a rod (6) when the engine is running at full speed: the rod (6) is connected to or connects one end of two levers (7, 8): the other end of one lever (8) is formed into a fork (9) and works in a grooved bobbin (10), which works on a perpendicular rod or shaft (11). To this rod or shaft are attached two balls or governors (12, 13) by means of two arms or rods (14, 15), which are secured to two other rods

(16, 17) attached to the grooved bobbin (10). The end of the other lever (7) is connected to the spindle (18) of a small steam slide-valve (19). This slide-valve when opened admits steam into a cylinder (20) fitted with a piston and rod. The piston rod is connected to a valve (21), so arranged that the steam is shut off from the engine by the port (22), and simultaneously turned on to a steam brake acting upon the engine by the port-hole (23). The disc (24) is marked on its front face with a dial, showing by an indicator finger the number of strokes which the engine has made at any given time in the journey, as well as the position of the cages in the pit. The indicator finger working on the disc (24) is revolved by means of a worm (25) and wheel (26), to which motion is imparted by means of four mitre-toothed wheels (27, 28, 29, 30) fixed—one (27) on the same shaft as the worm actuating the disc, two (28, 29) on a shaft at right angles to the worm shaft, and one (30) on a horizontal rod or shaft (31) passing through the pillar supporting the disc. This horizontal shaft is the main shaft of the apparatus, and one end of it is connected to the engine in such a way as may be suitable; the other end is supported by the same bracket (32) that supports the perpendicular shaft (11). On this end of the horizontal shaft is keyed a bevel-toothed wheel (33) working in another bevel-toothed wheel (34) keyed on to the perpendicular shaft (11), thus imparting motion to it and to the balls or governors (12, 13). On the top of the rod (6) a ball (35) is fixed for the purpose of overcoming the resistance of the pressure of the steam on the slide valve. At the pit top on the head gear two levers are fixed to connect in any suitable way to the apparatus in the engine house, so that, if for any cause the engineman raises the cage above a certain height over the flat sheets, the lever (7) of the apparatus will be raised and steam shut off from the engine and turned on to the steam brake.

It is claimed that the present system is a novel departure in a direction much needed, and it is hoped that by means of an open discussion the merit of the invention may be fully proved.

The PRESIDENT—You have all heard Mr. Cobbold's paper. I have only had the pleasure of hearing the latter portion; but I have been able to follow him, and to appreciate the very great measure of ingenuity that has been brought to bear upon working out this idea for the prevention of overwinding. It is a subject we are all interested in, as we are all liable to overwinding. In the last few years we have seen where serious loss of life has resulted from inattention, carelessness, or accident, to the engineman. Whatever the cause, we have seen the effect, and anything that regulates the engine *per se* seems to me to commend itself to our notice more than overwinding hooks, clever as they may be, inasmuch as the mischief may be done if the engine gets out of the control of the engineman. I do not suppose any man could be in a cage ascending as that did at Houghton Main without having his brains knocked out by a sudden stoppage, so that any appliance such as the one before us commends itself very strongly to my mind. I have not had an opportunity of looking further into the details, but it seems to be a very ingenious scheme, one which commends itself from its extreme simplicity. As far as I can gather, the dial itself is the means by which the steam is cut off primarily. The position of the cage in the pit is shown by that dial, and it can be regulated to the point at which you propose to cut off—the point at which, if the engine is travelling at its normal speed, it passes the pointer over the recess without dropping into it. The only question likely



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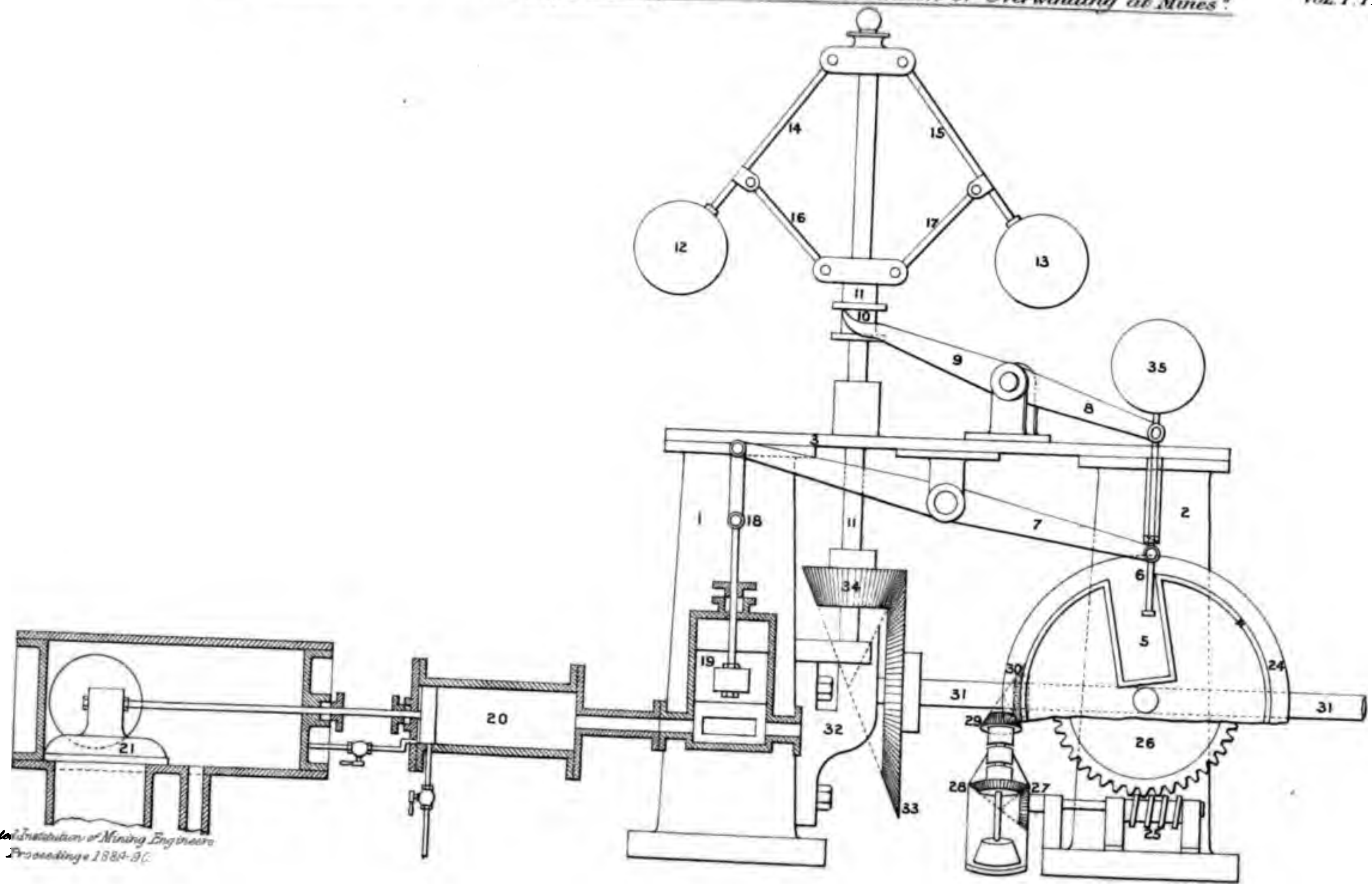
Proceedings 1889-90

To illustrate Mr. Cobbold's paper "An Apparatus for the Prevention of Overwinding at Mines". Vol. I. Plate II.



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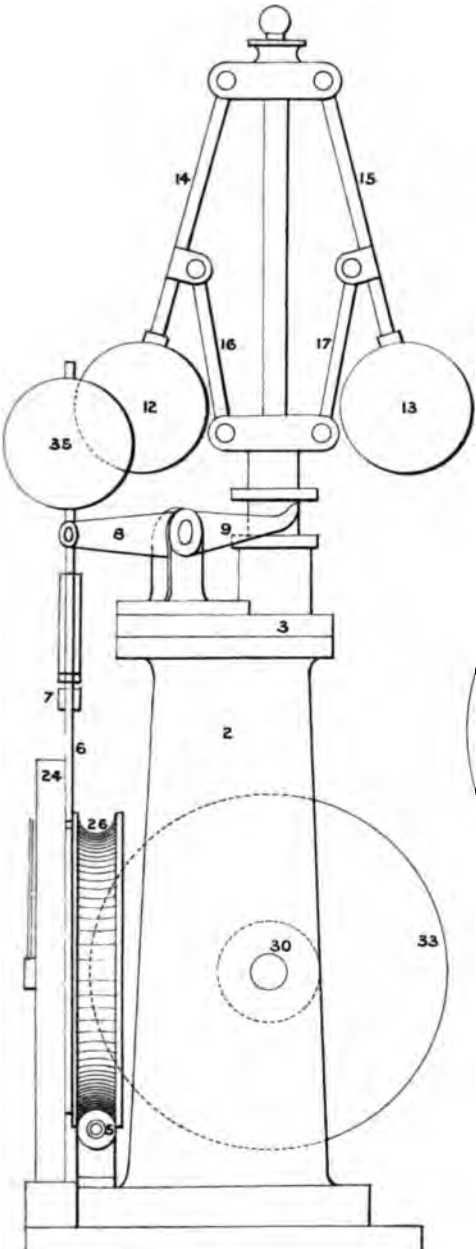

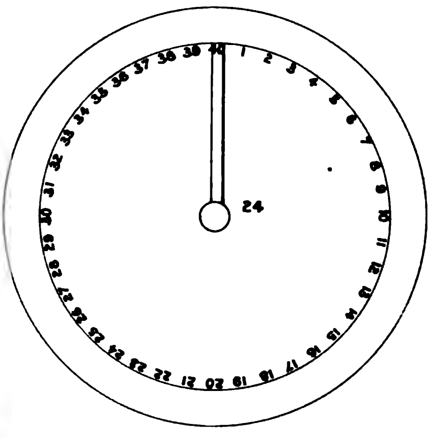

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to arise is, assuming that the key came out of the dial when the cage got into the shaft—when the cage was at the highest speed in the shaft—what would be the effect of cutting off there? There is, as many here will know, a particular arrangement for automatic cutting off. I believe, for instance, they have had it at Silksworth. I think that has been done in one or two cases with the automatic arrangement for cutting off steam. My only object in criticising is to elicit discussion on points that may be raised.

Mr. Lupton—We are much indebted to Mr. Cobbold for his paper, and for the very intelligible model before us, which enables us to understand the idea. I do not understand that any mechanic is going to pass an opinion on an apparatus of this kind the first time that he sees it, as we know the exceeding amount of ingenuity exercised to attain the same object by other engineers. We are looking for a perfect apparatus. This may be it; but we cannot say so until we have had the opportunity to study it. It is a question that appeals to us all, and it would be a great comfort to know that we could not be overwound. It would be a satisfaction to every colliery manager to know that his men could not overwind the cage through carelessness or accident. We are much obliged to Mr. Cobbold; and I beg leave to move a vote of thanks to him, that the paper be printed in the Transactions, and that the discussion be adjourned.

Mr. Durnford seconded the resolution, which was carried.

Mr. Cobbold—I thank you very much, and I will leave answering any questions until next meeting.

Mr. Arnold Lupton read the following paper on "Notes on the 'Medium Fan' (Patent)."

NOTES ON THE "MEDIUM FAN" (PATENT).

BY ARNOLD LUPTON, M.I.C.E., F.G.S.

Few subjects have excited more enthusiastic discussion among mining engineers than the merits of rival fans, and the reason is not far to seek. The subject is capable of limitation; it is possible to grasp all the main elements concerned, and the issues are definite and easily determined. Three conditions are required of a fan:—

1. That it shall produce the required ventilation without breakdowns.
2. That it shall work with the maximum of economy.
3. That it shall require the minimum of capital outlay.

The best fan is that which, giving its due value to each of these three conditions, gives on the average the best results.

The inventor of each fan now in the market claims the victory, and mining engineers choose their fan in a great measure according to the value they attach to each of the three conditions.

One engineer prefers the fan which cannot break down (he thinks), and leaves economy to take care of itself. Another engineer chooses the least expensive fan because he cannot afford a better. And a third goes in for economy of engine-power as the leading consideration.

The conflict of mechanical ventilators in this country has been chiefly fought during the last twenty-five years, and the slow but certain teachings of experience have deduced at least one determination for our use. It is this. That (in sporting phraseology) the centrifugal machine is first and the rest nowhere. The rest may have their merits, may in fact be very good, may continue to be used, and even here and there new ones be constructed, but nine out of ten, or perhaps ninety-nine out of a hundred, mine ventilators are centrifugal machines. The reasons of this victory of the centrifugal machine are soon discovered, and may be set down thus:—

1. With due care it may be designed and constructed so as to put a breakdown of the machine (as distinguished from the steam engine that drives it) out of the range of reasonable possibility.
2. It will produce any required quantity of ventilation.
3. It will produce any required pressure or vacuum (as measured by the water-gauge).
4. There are no valves, levers, or other parts subject to minor derangements, so that it is always in its proper working order.
5. It is the least expensive mechanical ventilator, except perhaps for unusually low water-gauges, or perhaps for unusually high water-gauges combined with small volumes.
6. It has not been proved that any other ventilator can work with greater economy.

It has ere now been recorded in history that when a great party has won a conspicuous victory, that rival leaders of that party have contended for a division of the spoils; so it has happened with the ventilators. The centrifugals were victorious easily: then came a greater contest between rivals in that camp.

Guibal and Waddell chiefly held sway, Rammell established himself here and there, then Schiele pushed his victorious way, and now Capell is cutting a road to the front. Modified forms of the Guibal (such as the Leeds fan) have been successfully introduced, and numerous small fans of slightly varying design have been used.

Those who take pleasure in sharpening their wits upon the grindstone of argument, may derive satisfaction from the reflection that it is not likely that there will ever be unanimity of opinion as to the merits of rival fans. But as to why it is so difficult to say which fan is best it is not so easy to dogmatise. Perhaps the following are among the chief reasons:—

1. As to the first cost of a fan, this depends on many considerations independent of its principle. For instance—

The state of the market for engines and ironwork.

The finish and more or less permanent nature of the construction.

The profit of the vendors.

The cost of brickwork and masonry at the mine in question.

The stringency of the book-keeper in charging all items to capital cost.

The items included, such as drift leading to fan, covering of shaft top, boilers, steam pipes, condensers, reservoirs, cooling ponds, etc.

It must be evident that for a real comparison of first cost all these elements require careful adjustment.

2. As to breakdowns. It is evident that, although one sort of fan may be more liable to breakdowns than another, yet if the relatively weaker sort can be made of sufficiently sound materials, and good workmanship, so that in point of fact it cannot and does not break down, then the theoretical advantage of the other sort has no great practical value.

3. As to economy in working. This includes four items—attendance, repairs, materials, and steam power. The attendance means enginemen and enginewright's supervision. The repairs mean minor repairs, which do not amount to breakdowns, such as tightening keys, replacing rivets or bolts, replacing rotten wood or rusted iron, painting, new brasses on bearings, repairs to the steam engine, such as piston rings, adjustment of valves, etc. Materials mean oil, grease, waste, belts, and ropes.

The steam-power means the weight of steam required to drive the fan, the cost of which is fuel, water, boiler repairs, insurance, and stoker's wages.

It is evident that in actual experience the cost of working a fan will depend on a great many conditions that are altogether independent of the merits of the fan itself. Good fuel, good stokers, good water, good boilers, good engines, good oil, good enginemen (combined) will produce much greater economy of working than the difference in advantage between any two of the better classes of fan.

In the endeavour to compare different sorts of fans, it is therefore difficult, if not impossible, to take as our guide the actual costs of working, and we have to assume an equality of economy in the boilers and engines, and simply to compare the relative horse-power required to produce a given amount of ventilating work. This is usually done in the following way:—

1. To ascertain the work done in the steam engine by means of indicator diagrams of steam pressure and counters of the speed, from which the work done every minute is ascertained in foot-pounds or horse-power.

2. To ascertain the useful work done upon the air of the mine by the fan. This is done by measuring the air that passes through the mine with anemometers, and ascertaining the pressure required to produce the air current. The pressure that is measured is the difference between the atmospheric pressure at the outside of the fan buildings, and which is unaffected by the working of the fan and the pressure inside the drift which connects the upcast top with the central orifice of the fan. It

is evident that the difference between these two pressures is due to the action of the fan, assuming equality of temperature. This difference of pressure is measured by its effect on a column of water. A cubic foot of water at about 50 degs. weighs about 62·4 lbs., and therefore a column one square foot area and one inch high weighs 5·2 lbs. Thus a difference in pressure between the inside and outside of fan drift of 5·2 lbs. will be balanced by a column of water one inch high, and the water-gauge will be in like proportion for other pressures. *It is this pressure which forces the air through the mine, and which operates upon every cubic foot of air as it enters the mine and passes through,* in a manner comparable to the pressure of steam upon the piston of an engine. The total work done by the fan is ascertained by multiplying the pressure which the fan produces in lbs. per square foot by the volume of air in cubic feet upon which this pressure acts, and stating the result as foot-pounds of work done, or as horse-power in the air. This horse-power in the air is stated as a percentage of the horse-power of the engine, and is called "useful effect." It is sometimes argued that this is not a scientifically accurate mode of ascertaining the useful effect, because the amount of ventilation produced in a mine may be assisted by the temperature of the upcast. This, however, does not really affect the question. The ventilation produced by a fan depends on many circumstances, and may be increased immensely by opening doors in the mine and so shortening the air course, or it may be diminished by shutting doors and so lengthening the air course; and, again, this lengthening of the air course may be counterbalanced by heating the upcast (say by exhaust steam from an underground engine). These considerations however are all beside the question, for it is immaterial as regards fan efficiency whether the air is brought to the fan by a short course, or by a longer course assisted by temperature. In each case the fan passes equal quantities of air, and produces the same pressure upon each cubic foot that passes. The writer therefore maintains that the usual method of ascertaining work done by a fan is scientifically correct, as well as being practically the most useful.

It is sometimes said that fan efficiencies cannot be compared unless the competing fans are tried at the same pit. But to try different fans at the same pit would not decide the relative efficiencies of different descriptions of fan, because one description of fan may be best suited for dealing with large volumes at a low water-gauge, and another for small volumes at a high water-gauge, and a third for large volumes at a high water-gauge, and a fourth for small volumes at a low water-gauge. In fact, a fan has to be specially designed to suit the conditions of the mine at which it has to work.

As a matter of scientific competition, the palm should be awarded to the fan which under any conditions commonly found in practice has, as a matter of fact, given the highest percentage of useful effect. We now come, however, to the real difficulty, and that is the impossibility of *absolute* accuracy in measurements and the great *difficulty* of approximate accuracy in the measurements required in the cases in question. These difficulties are as follows:—

1. Indicator diagrams. These may be inaccurate from faults in the springs, strings, levers, pipes, taps, etc., and faults in the observer; moreover, the measurement of a small diagram cannot be perfectly accurate. An indicator diagram may be measured to give a result within 5 per cent. of the truth (doubtless greater accuracy is often got).

2. It is difficult to measure the speed of the engine. An ordinary counter is of little use for accurate observations. A careful man with a good watch may time a slow speed engine to within 1 per cent. For really accurate observations a speed recorder can be constructed, but these have been rarely used in the case of fan engines. Such a speed measure or velocimeter is shown in Figs. 1 and 2, Plates I. and II. A pen

actuated by clockwork beats seconds; a strip of paper is drawn under the pen by a thread from a revolving shaft connected to the engine; the speed of the engine each second is recorded on the paper by dots.

3. Steadiness of speed is essential at the moment when the diagram is taken. If the engine is gaining speed the diagram shows a much greater power than is required to maintain speed, and if it is losing speed the diagram shows a much less power than is required to maintain speed; and an almost imperceptible variation in the velocity may be accompanied with a large variation in the diagram, because the momentum of the engine and fan will tend to maintain a steady velocity during a brief fluctuation of steam pressure. In fact, a diagram representing the work done requires to be taken with steam at a steady pressure. Accuracy in this respect may, however, also be tested by taking a great number of diagrams.

The exact diameter of the cylinder is seldom taken in ordinary fan observations, because it is not usually convenient to remove the cylinder cover. The exact length of the stroke requires to be carefully measured.

When, however, every care has been taken, and the horse-power ascertained to within 5 per cent., the result may be vitiated if the bearings are not in good order. The bearings may be hot through some fault not connected with the principle of the fan. If the bearings are only kept cold by a stream of water, the loss of power is probably still occurring though the bearings are cool. Assuming that with ordinary lubrication a bearing is maintained at a temperature of 160 degs., a temperature at which the hand can be placed on it without injury, a considerable proportion of the engine-power may be absorbed. If there are two bearings for a shaft, say 8 inches in diameter, and the total superficies of heated metal, including pedestal, bed plate, etc., is 16 square feet, with a temperature exceeding that of the air and building by 100 degs., the radiation for the bearings will be, roughly speaking, about 16 thermal units a minute, equivalent to a loss of 12,362 foot-pounds a minute. There will be about an equal loss by convection of the air, and a further loss by conduction of the shaft, etc., say a total loss of 1 horse-power. Of course, a rapidly heating bearing may absorb much more power. Suppose that a total weight of shaft and pedestals of 1,500 lbs. is heated from 60 degs. to say an average of 160 degs. in 100 minutes. Then 11,580,000 foot-pounds of work would be done in increasing the heat, and about 617,600 foot-pounds of work in maintaining the heat, or a total of 12,197,600 foot-pounds in 100 minutes, equal to an average of 3·69 horse-power, *or* say about 9 per cent. of a 40 horse-power engine.

We now come to the difficulties of measuring the work in the air:—

1. Inaccuracies of anemometers. For the comparison of fans the same anemometer ought to be used in each case, or anemometers tested by the same standard, and the air velocity ought to be the same. This equalization of air velocities may be obtained by choosing as the place of measurement a larger or smaller section of road as the case may be. In every case the air road ought to be straight and smooth. To measure the air at a frame of different shape or area to the drift is to invite inaccuracy, because the currents of air will not be parallel to the axis of the anemometer. It is seldom that a fan drift is so shaped as to give any hope of really accurate measurements; but it is generally possible by some expense to construct a suitable channel for air measurement. Such a channel should be straight for some feet, say not less than 6 feet. The velocity of air should be approximately equal on every part of the circumference. If this is the case, the air currents will be parallel to the axis of the channel, and therefore to the axis of the anemometer. (See Figs. 3 and 4, Plate III.)

The ordinary method of measuring the velocity for a half minute or one minute is a mere approximation, and it is impossible to approach nearer than 1 per cent. in the

mere timing of the trial; but the errors resulting by holding the anemometer longer in one current than in another must be still greater. For accurate measurement, anemometers ought to be fixed in each division of the air course. They ought to be run for at least ten minutes, and be stopped or started by mechanical appliances by an operator at a distance. Such appliances might be operated by pneumatic or hydraulic power in pipes. The total error in air measurement must frequently be from 5 per cent. to 10 per cent. in cases where the most impartial care is taken.

The next difficulty is the water-gauge. In the ordinary tube it is impossible to read to within 5 per cent. of the actual pressure with a perfectly steady gauge.

The muffled gauge tube employed by Mr. Capell is a great assistance in steadying the gauge. But all observers have found that the gauge varies very much according to the position in the drift of the inner tube.

Currents and eddies of air entirely vitiate the indications, making the apparent water-gauge often 20 per cent. or 30 per cent. higher or lower than the actual water-gauge.

If the air tube is turned, so that the air current runs against it, the water-gauge measurement will be lowered very greatly. If on the other hand the tube be taken into the orifice leading into a small fan, the suction caused by the abnormal velocity will fetch up the water-gauge about 20 per cent. above the correct reading.

When all these difficulties are taken into account, it is not surprising that efficiencies of fans, as stated by different observers, vary very greatly. The present writer has designed, patented, and erected a fan which he proposes to describe. In designing the fan, the endeavour was made to combine the best qualities of other fans. It is a compound of the Waddell and the Guibal, with variations in detail, and with some additions upon which the patent is founded.

The fan is called the "Medium Fan," because in its design extremes have been avoided. It is neither big nor little; neither light nor heavy; neither fast nor slow. The author, without wishing to lay down the law, submits for consideration and discussion the following propositions:—

1. *The weight of fans, of the same kind, varies as the cube of the diameter, or in other words a 40 feet fan will be eight times as heavy as a 20 feet fan.*

2. *The work done by a fan within suitable velocities, all other things being equal, varies as the cube of the velocity of the fan tips.*

3. *Within moderate or medium dimensions, the water-gauge produced by fans varies with the squares of the velocities of the fan tips.*

4. *The diameters of fan shafts of the same kind will be, roughly speaking, proportional to the diameter of the fans.*

5. *Journal friction is, roughly speaking, proportional to weight multiplied by velocity of surface of journal.* (The writer is acquainted with the recent elaborate experiments in journal friction.)

It follows from these propositions that the journal friction of a 40 feet fan will be eight times the journal friction of a 20 feet fan, having the same speed of periphery and doing the same work, other things being equal. But other things will not be equal, because in dealing with great weights there often arise great practical difficulties in keeping shafts cool, so that the journal friction of the 40 feet will probably be more than eight times that of the 20 feet fan. On this account the smaller fan is to be preferred, and in this conclusion the writer expects the hearty concurrence of Messrs. Schiele and Capell.

6. *When a large volume of air is dealt with, there is great friction and consequent loss of power if it is crowded through a little fan.*

It is difficult to calculate this loss; but there is reason to believe that in some small fans the internal resistances of the small orifice leading to the fan amount to

10 per cent. or more. On this account a fan of moderately large dimensions is to be preferred to a very small fan, and in this conclusion the writer feels sure that Messrs. Guibal and Waddell will agree.

Fans for mines are usually divided into two classes. Those of large diameter, of which the shaft is a continuation of the crank shaft of the engine, and those of small diameter in which the shaft is driven by a belt from the fly-wheel of the engine. In both these classes the engine is slow speed, say 40 to 60 revolutions, with a 2 feet or 2 feet 6 inch stroke, giving a piston speed of from 160 feet to 300 feet a minute.

7. *It is both possible and economical to run fan engines at a higher piston speed than 300 feet. Some engines work successfully at 500 revolutions a minute, such as the Willan's engine, etc. An ordinary engine may, if well constructed, be driven up to 120 revolutions, with a 2 feet stroke, giving a piston speed of 480 feet;* the quiet and safe working at this speed being merely a matter of design and workmanship.

The "Medium Fan" is designed in accordance with these seven propositions. The diagram shows its design. (Figs. 5 and 6, Plate IV.) It may be made from 15 to 25 feet diameter. In the fan now running the diameter is 20 feet; it is constructed of steel plates, forming two discs (P P), as in a Waddell or Rammell fan. The distance between the discs in this example is 9 inches at the periphery and 2 feet 6 inches at the centre. There are 12 vanes or blades (V V) connecting the discs. The orifice for the air (A A) is 7 feet 6 inches diameter. The fan is riveted to a cast iron boss on a 7 inch shaft with 5 inch journals. It is driven by a vertical engine with 13½ inch cylinder, and 2 feet stroke. The fan runs in a chamber of brick; one-half of the chamber is roofed with a curved cover of wood and iron (F F). The other half is open and carried up three feet above the top of the fan, and so forms a chimney or delivering outlet, which is intended to have a similar effect to the Evasée outlet of the Guibal fan. Where the cover of the chamber ends there is a vertical wooden partition (D D) exterior to the fan reaching down to the centre of the fan, with an opening just large enough for the fan to run in it.

The effect of this partition is to prevent air in the chamber from travelling with the fan, and to throw the air on the exterior of the fan upwards. The interior space of the chamber (E E) outside the fan is so proportioned as to leave just sufficient space for the air escaping from the fan to travel in the same direction as the fan till it reaches the outlet, up which it escapes. The effect of this proportionment combined with the partition above-named is to utilise the friction of the exterior of fan in assisting the delivery and escape of the air. This at least was the intention of the design.

Since the fan was erected the writer has made some observations to ascertain the useful effect. In view of all the difficulties in obtaining results the following figures are given for what they are worth. A glance will show that there are many inconsistencies, and all that can be said for them is that with such appliances as were at hand, and such time as he could spare for the work, an honest endeavour was made to ascertain the facts.

Richard's indicators were applied to the top and bottom of the cylinder, and a Biram's anemometer, made and specially tested by Davis of Derby, was used to measure the air. As a rule the bearings of the fan, with ordinary or needle oil cups, run cold, but sometimes, especially when lubrication is entirely neglected and there is no oil in the oil cups, they heat up.

The average useful effect as shown above is 73 per cent. These are not all the observations made, and are not quite the best, nor the worst results. The average given may be more or less than the truth. The anemometer measurements in the pit are probably more trustworthy than those in the drift, as in the latter the speed is excessive and the air-way twisted.

MEDIUM FAN.—OBSERVATIONS AND CALCULATIONS.

Diameter of Fan at tips = 20 ft.; of central orifice, 7 ft. 6 in. Width of blades at centre, 2 ft. 6 in.; at tips, 9 in. Cylinder, about 13½ in. Stroke, about 2 ft. Water-gauge readings—at side drift = S.D.; at central orifice C.O. Weight of Fan, including crank-shaft, about 5½ tons. Clear area of central orifice, about 30 sq. ft.; of circumferential orifice, about 46 sq. ft. Area of tangential orifice, say 12 sq. ft. × 3 = 36 sq. ft.; of final outlet = 57 sq. ft.

No. of Observation.	Revolutions per Minute.	Water-Gauge in Inches. Calculated $H = \frac{v^2}{64}$.	Water-Gauge in Inches. Observed.	Water-Gauge in Inches. Observed Higher than Calculated Per Cent.	Air Volume. Cubic Feet per Minute	Work in Air. Foot-Lbs. per Minute.	Steam Pressure Indicated Lbs.	Work in Engine. Foot-Lbs. per Minute.	Useful Effect or Ratio of Work in Air to Work in Engine, in Percentages. As Observed.	Deducting for Friction of Engine and Bearings. Steam Pressure, 1·7 lbs. per sq. in.	Deducting for Friction of Engine and Bearings. Steam Pressure, 3 lbs. per sq. in.
1	51½	0·66	0·80 S.D.	21	Measured in Pit. 52,676	219,132	10·00	290,460	75·4	*90·9*	*107·0**
2	77	1·48	1·80 S.D.	20	In Pit. 81,285	760,827	22·40	972,787	78·2	*84·6*	*90·1*
3	60	0·91	0·95 C.O. S.D.	4½	Measured in Fan Drift. 51,392	253,876	11·45	387,468	65·5	*76·9*	*88·7*
4	92	2·14	2·50 S.D.	16	Fan Drift. 81,554	1,060,212	28·00	1,452,864	73·0	*77·6*	*81·7*
5	12	...	...	...	...	1,779	3·40	23,011	...	...	...
6	20	...	...	...	...	8,200	2·50	28,200	...	...	...
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

Observations 5 and 6 show the steam pressure as indicated at slow speeds. If the work done in the air is deducted, the pressure required to overcome engine friction is 3 lbs. and 1·7 lbs. respectively.

Columns 11 and 12 have been worked out to show the efficiency of the Fan as distinct from the efficiency of the engine and bearings.

* It is evident that the result in column 12, where a fan efficiency of 107 per cent. is shown, the engine friction being taken at 3 lbs., is wrong. Whether the amount set down for engine friction is excessive or whether some other figure is inaccurate can only be determined by repeated observations with arrangements better calculated to ensure accuracy.

The calculated water-gauge is obtained from the formula $H = \frac{V^2}{64}$ where H is air column in feet of the temperature of the air in the fan, and V is velocity in feet per second of fan tips. In the above cases the observed water-gauge is more than the calculated water-gauge by 21, 20, 4½, and 16 per cent. respectively. By varying the position of the tube attached to the water-gauge, enormous variations of measurement may be obtained. Those given are considered fair results; but the discrepancies prove that there is inaccuracy in the record.

After making allowances for obvious inaccuracies and discrepancies, the result shows a high efficiency, and this may be due not only to lightness of the machine, but also to careful adjustment of all the air passages in the fan chamber to the size necessary to ensure a continuous and regular flow of air through every part of the fan and fan chamber, and by this means to minimise the "re-entry," and also to the utilisation of the interior surface of the fan to assist the delivery.

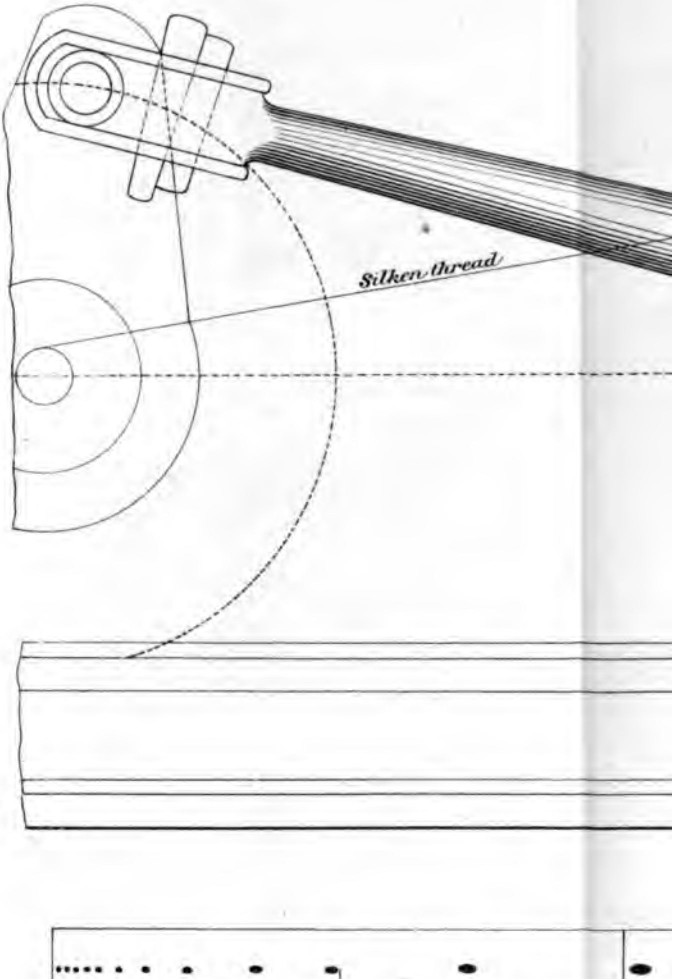
The fan produces at the mine, where it is now, about 1,000 cubic feet per revolution, and as the circumference is nearly 63 feet, there issues about 16 cubic feet of air for each foot of the circumference per revolution; and if the fan made 63 revolutions a minute, then 1,000 cubic feet must issue each minute from each foot of circumference, and as the width is only 9 inches, the velocity of issue in a radial direction is about 1,333 feet, whilst the velocity of circumference or tangential velocity is about 3,969, or say about three times the radial velocity of the air. But the air can only issue from the fan at the 12 circumferential openings between the vanes, and these openings occupy the whole circumference, except for the thin dividing plates; but regarded as openings for the escape of air tangentially they have a much less area. The length of each opening is in fact equal to the versed sine of the arc between two vanes (or 30 degs.). This versed sine is only 1·34 feet, whereas the arc is 5 feet 3 inches or four times the length. It follows therefore that a simple tangential projection of the air will not suffice to clear it out of the fan, and that a slight radial projection is necessary. The air issuing from the fan enters a channel only large enough to take it when the velocity of projection is maintained, and this channel is only enlarged when the final outlet is reached and a diminished velocity of delivery helps to increase the vacuum.

In order to ensure a satisfactory result the width of the fan, the diameter of the orifice, and the dimensions of the chamber must be varied to suit the quantity of air required. The volume of air passing with a given water-gauge depends on the airways of the mine. Engine-power is all that is required to get any required volume of air, and this of course must be provided to suit each particular case.

This fan has now been running eighteen months. The bearings are cold, the consumption of steam very little; it gets little attention beyond occasional lubrication, and in two years from the day it started it will have saved—so the writer calculates—as compared with the cost of working the furnace, the entire cost of erection, including buildings, fan drift, and all capital costs except the boilers (which were previously in existence).

The PRESIDENT—You have all heard Mr. Lupton's paper, which travels over a good deal of ground. It has gone over ground considerably beyond a medium fan. He has astounded me with his proposition. We have got now to ventilate with nothing. In fact if we got the fan we should have a little margin for driving the winding engine, and we have only to get fans enough, and we shall be able to drive all our machinery for nothing. But in order to follow Mr. Lupton, I should like to

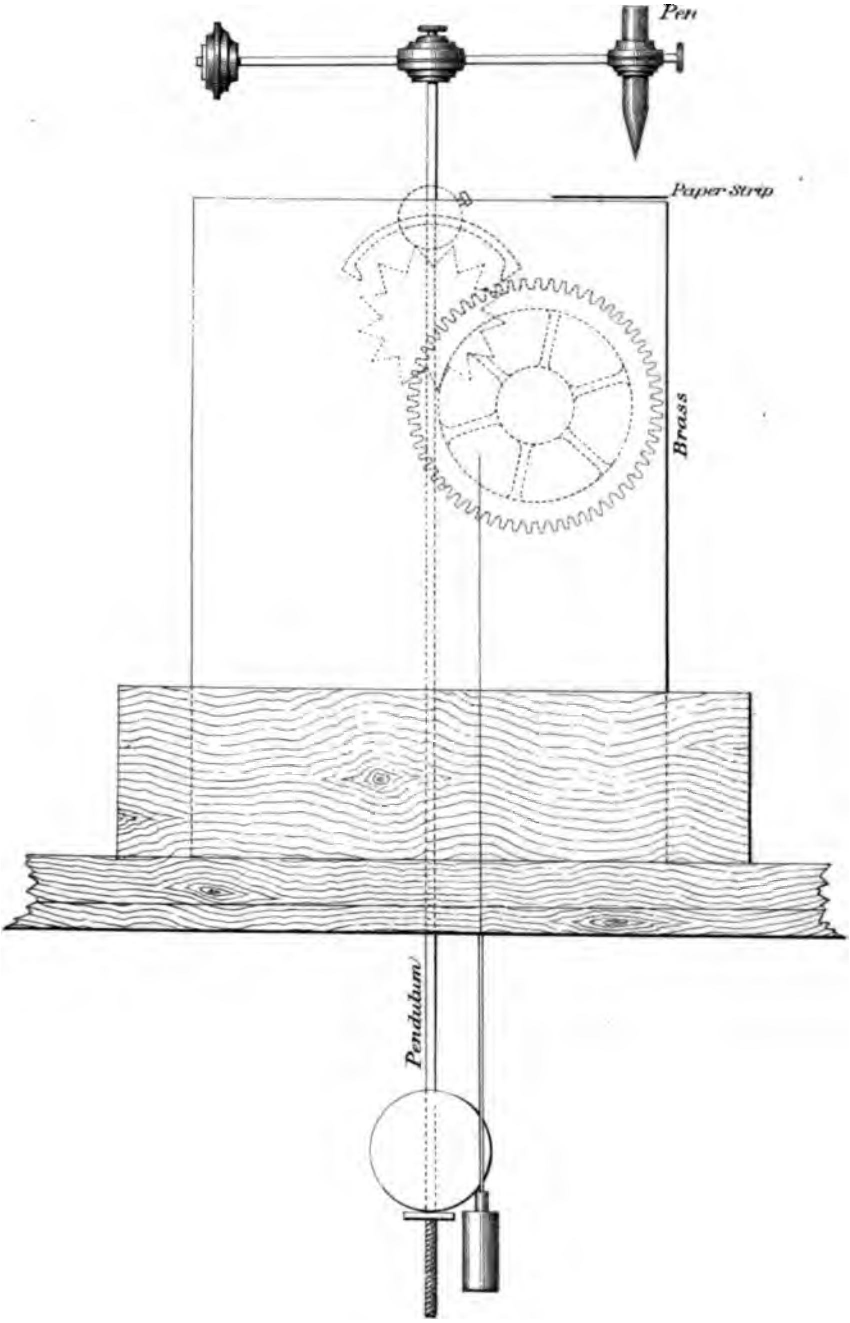
HORIZO



To illustrate Mr. Arnold Lupton's paper on "The Medium Fan".

THE VELOCIMETER.

Fig. 2.



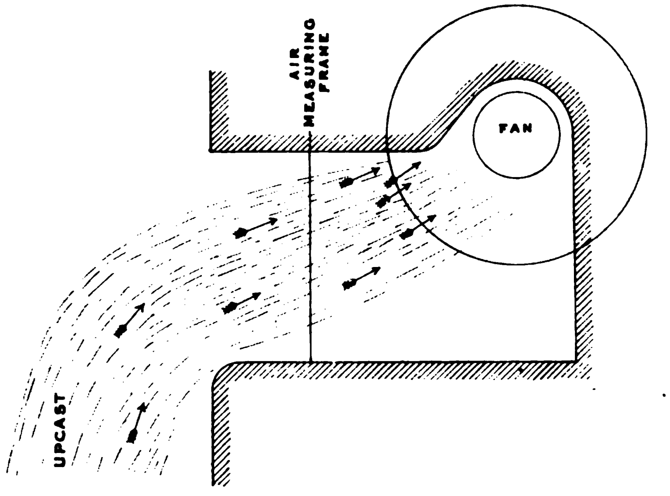
Scale Half Natural Size

Federated Institution of Mining Engineers
Proceedings 1889-90

Andw Reid Sons & Co Lithrs. Newcastle

To illustrate Mr. Arnold Lupton's paper on "The Medium Fan".

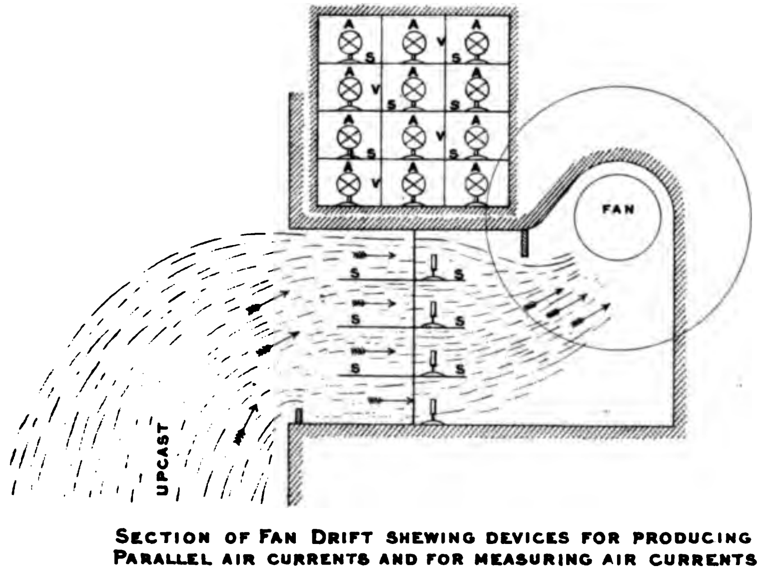
FIG. 3.



SECTION OF FAN DRIFT SHEWING AIR CURRENTS NOT PARALLEL TO DRIFT.

FIG. 4.

CROSS SECTION OF DRIFT



SECTION OF FAN DRIFT SHEWING DEVICES FOR PRODUCING PARALLEL AIR CURRENTS AND FOR MEASURING AIR CURRENTS WITH SOME APPROXIMATION TO ACCURACY.

SS HORIZONTAL DIVISIONS OF FAN DRIFT
VV VERTICAL Do. Do.
AA ANEMOMETERS STOPPED AND STARTED SIMULTANEOUSLY BY MECHANICAL, PNEUMATIC OR HYDRAULIC CONNECTIONS.

And^w Reid, Sons & C^o. Lithos. Newcastle

To illustrate Mr. Arnold Lupton's paper on "The Medium Fan".

THE MEDIUM FAN (PATENT)

VERTICAL SECTIONS.

FIG. 5.

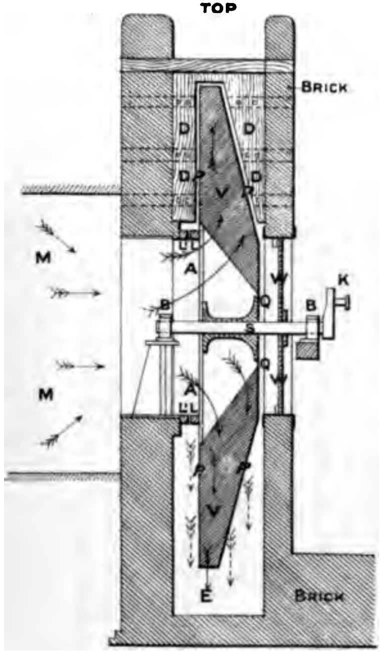
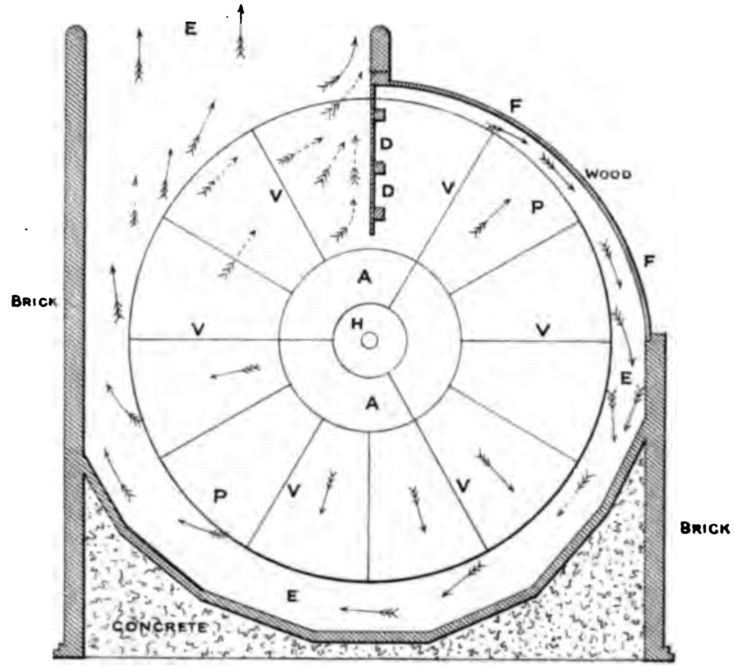


FIG. 6.



— REFERENCE. —

ARROWS shew direction of Air Currents { entering / traversing / leaving } the fan

DOTTED ARROWS shew some of the Air Currents caused by the Exterior surface of the fan.

Andw. Reid Sons & Co. Lithrs. Newcastle

ask how he gets at his 70 per cent. of useful effect in air; and I should like to ask what horse-power he calculates to be in the 81,000 feet of air with that water-gauge; and what horse-power he calculates was necessary to produce it with his engine?

Mr. Lupton—I put it down as 1,452,864 foot-pounds of engine-power, which is 44 horse-power, and there are 1,060,202 foot-pounds in the air or 32 horse-power.

The President—I take it there is 40 horse-power in the air. What size steam cylinder would be used to get it?

Mr. Lupton—A 13½ inch cylinder, two feet stroke, and 28 lbs. average indicated pressure.

The President—They are certainly astounding figures. If there is a 13 inch cylinder engine, driving a fan 20 feet in diameter at that number of revolutions per minute, I should like to go and see it. It is a revelation to me. There is no Guibal fan, and no Waddle fan in this country with anything like that size of engine, or double that size of engine, that is running at anything like that speed with a fan of that diameter. There are many gentlemen here who have fans running, of not exactly that type, but with which they have to get the same periphery speed. I know of no Waddle fan that is getting more than 60 per cent. of useful effect, and I do not think more than three or four in the country are getting that—46 per cent. is about the mark. The Guibal, with Coxe's patent, gets 56 per cent. Mr. Coxe reckons to get 70 per cent. of useful effect. With the Schiele I have not been able to get more than 50 per cent. of useful effect. I know we cannot drive a Schiele fan, running direct on any 13 inch cylindered engine—we tried with a 14 inch cylindered engine with an 8 feet 6 inch Schiele fan—at more than the speed set down for a 20 feet fan on yours.

Mr. Lupton—Perhaps there was a lot of wind to pull it up.

The President—No, the air was sadly deficient, or we should not have abandoned the system of driving direct. I went carefully into it in order to get the result. The same thing obtained at Cortonwood, where they began driving these high speed fans direct. With the Schiele fans we cannot get more than 50 per cent. Mr. Capell declares that he can get 75 per cent. to 78 per cent. with his fan. I do not know about that, but now we get 107 per cent.

Mr. Gerrard—I quite agree with our President. The figures Mr. Lupton has placed before us to-day are astonishing. I scarcely think Mr. Lupton so wise in placing on record such highly absurd deductions as that of claiming to obtain 107 per cent. of useful effect from this fan. We shall be better able to discuss the paper after reading it. I propose that our best thanks be given to Mr. Lupton for the trouble he has taken in compiling the paper, that it be printed in the Transactions of the Institute, and that the discussion on it be adjourned.

Mr. G. B. Walker—I have much pleasure in seconding the motion. It occurs to me that the deductions for friction were made by Mr. Lupton in an imperfect way, by running the engine at uncertain speeds, and that the latter one was the more imperfect. If the 1·7 is the real measure of friction, as it gives more probable results, then the 3 is probably a mistake. I think we might take the first of those columns as being the more approximately accurate.

Mr. Lupton—I should be sorry for you to take anything as accurate. One of the chief objects of my paper is to show the difficulty of getting accurate results. If I reduced the 107 per cent. to a possible figure, I might have led you to suppose the other figures were absolutely accurate, whereas they are only approximations.

Mr. Gerrard—I certainly understand Mr. Lupton put forward his calculations as being accurate. If I have misunderstood him I apologise. Would it not be well to draw the line clearly between the actual accurate results and those put forward as suppositions?

Mr. BROWN—In taking the efficiency of the fan, if you take the friction of the engine off and the friction of the fan off, you are sure to get 100 per cent. If you take anything off for friction you cannot get the true results—it is impossible. If you take the power in the steam cylinder and the power in the air you get a true result. If you get the power in the air plus the friction of the engine you get no comparison at all. A bad engine would give the same result as a good engine in that case. I think nothing should be taken off for the friction of the engine, and then if Professor Lupton attains 75 per cent. it is highly satisfactory. Getting up to 90 per cent. and 100 per cent. it is evident there is something wrong, and the wrong is in taking into account the friction of the engine from the power of the engine. The engine has that power to exert, and you are bound to debit it to the system. You are bound to include the friction of the engine and of the fan.

The PRESIDENT—There is no doubt that to measure fairly you must compare the power in steam with the power you get out at the end, whether the steam is put through a good or a bad engine.

Mr. LUPTON—Suppose you get a result apparently, and test the result by the apparent friction of the engine, and get the absurd result of 107 per cent., you know the figures are wrong—you know they are figures requiring testing and correcting, and that is the reason why I worked out the column with engine friction 3 lbs.

The PRESIDENT—I do not think you should take off the friction at all. You cannot pass power through an engine without friction. You must pass your power through an engine, and there must be loss in passing power from a primary to a secondary position.

Mr. LUPTON—I think it is correct, for the purpose of comparing fans, to deduct engine friction, because there may be excessive friction in an engine from tight piston rings, air pump, and other causes easily remediable, which might tell against a fan unfairly.

The PRESIDENT—Your taking the friction off is as practical as squaring the circle. You have got something out of nothing. The result is that people are bitterly disappointed both as regards first cost, wear and tear, and actual result. I would suggest, as these figures will be laid before other Institutes besides our own, that if the calculations as to friction were omitted, it would increase the value of the paper both as affecting your fan and as being of interest to this Institute and others.

Mr. LUPTON—I did not measure the air when the fan was standing, or at a very slow speed, but merely calculated the work in the air at the slow speeds from the results obtained at higher speeds, because you cannot measure the water-gauge at a very slow speed; there is no indication.

Mr. T. W. H. MITCHELL—Taking the natural ventilation, we had to run the fan to get the water-gauge level; there was a pull against it.

The motion was then carried.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, DECEMBER 14TH, 1889.

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, and in reporting the proceedings of the Council said there was not much new to tell except with reference to the Federated Institution of Mining Engineers. Since the last general meeting the Council had met at York, and it had been decided that the first general meeting of the members of the different Institutes should take place at Sheffield on the 22nd and 23rd of January. A full programme for those days would be issued as soon as the necessary details were obtained from the officials of the Midland Institute, who had most of the arrangements in hand. But, in a general way, he was already in a position to explain that the first day would be taken up by the reading of papers, visits to a few works in the immediate neighbourhood, a dinner, etc. The next day would be given up entirely to visits to works and collieries, especially such collieries as had any specialities worthy of notice. As soon as the programme was ready, it would be sent to all members; and as Secretary he would like them to let him know as early as possible whether they were going or not, as a good many of the arrangements depended on the number of members going, and it was only fair to those who had taken the trouble for them that they should have some idea of the number likely to attend.

Mr. COCHRANE asked if the arrangements for the Sheffield meeting would be such as to allow of members leaving Newcastle on the morning of the 22nd, or must they be there the previous day?

The PRESIDENT said he had visited Mr. Rhodes, the President of the Midland Institute, the previous week, with a view to making some arrangements for the meeting, and amongst other things it had been arranged that any one who had a special wish to see coal-cutting and electrical appliances in connection with coal mining, would not only have an opportunity of seeing these things the day after the meeting on which papers would be read; but special arrangements would be made by which they could see them in the morning prior to the meeting, and by that means members could make their arrangements to suit their own convenience. Those who liked could go on the Tuesday night, and time tables and other particulars would be given in a few days. Inasmuch as the Midland people thought they had something to show both as regards coal-cutting by machinery and the application of electricity to various acts of mining, the transmission of power, and so on, the privilege had been given of seeing these various machines before the discussion as well as afterwards. Those whom it would suit best could go on the Tuesday night, others could go on Wednesday morning.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. T. Colquhoun, Mining Engineer, West Stanley Colliery.

Captain William Charles Chitty Erskine, Inspector of Mines, Kimberley, South Africa.

Mr. William Tasker Hallimond, Mining Engineer, Manager of Van Ryn Gold Mining Company, Limited, Boksburg, Johannesburg, Transvaal.

Mr. Jethro Longridge, Colliery Manager, Burradon Colliery, Newcastle-on-Tyne.

Mr. Thomas Lowden, Colliery Manager, Hamsteels, near Durham.

ASSOCIATES—

Mr. William Draper, Assistant Under Manager, New Seaham Colliery, Sunderland.

Mr. John William Forster, Assistant (Certificated Manager, under Act), Silksworth Colliery, Sunderland.

Mr. John Charles Hall, Surveyor, Trimdon Grange Colliery, Co. Durham.

Mr. Francis Burdett Johnson, Mechanical Engineer, 1, Charles Street, Marsden Colliery.

Mr. John Riddell, Under Manager, Shilbottle Colliery, Lesbury, R.S.O.

Mr. John Southern, Master Wasteman, Heworth Colliery, Newcastle-on-Tyne.

Mr. Matthew Walton, Assistant Manager, Dearham Colliery.

The following gentlemen were nominated for election :—

MEMBER—

Mr. Daniel Henry Bayldon, Mining Engineer, Thames Gold-Field, New Zealand ; and 3, Draper's Gardens, London, E.C.

ASSOCIATES—

Mr. Sidney Bates, Surveyor, etc., The Grange, Prudhoe-on-Tyne.

Mr. John Bell, Under Manager, Wardley Colliery, Newcastle-on-Tyne.

Mr. Thomas Hepburn, Under Manager, South Street, Langley Park, Durham.

Mr. Robert Richardson, Under Manager, Throckley Colliery.

Mr. George D. Ridley, Colliery Surveyor, Tudhoe Colliery, Spennymoor.

Mr. Andrew Watson, Colliery Engineer, New Seaham Colliery, Sunderland.

Mr. THOS. BELL, H.M. Inspector, referring to the list of members for election, asked what part of the Mines Act provided for an "assistant manager."

The SECRETARY—I don't know.

Mr. BELL—Nor I. I see there is also "assistant under manager"; I don't know that official either.

Mr. G. B. FORSTER—I don't think he comes under the Act.

The PRESIDENT—I suppose the particulars are copied from the nomination paper as it comes to us.

Professor LEBOUR—That is so.

Mr. R. F. BOYD read a memoir of the late Mr. E. F. Boyd, F.G.S., which is published separately with a portrait in pamphlet form, an abstract of which, containing the particulars of his professional career in connection with the coal trade, will be given in the next part of the Proceedings.

The PRESIDENT said it fell to his lot to perform a pleasing duty, and yet a feeling one. They had heard a memoir of one who, twenty years ago, was President of the Institute, and therefore one of his predecessors. He (Mr. Marley) also appeared in another capacity as a pupil of Mr. Boyd, so that he felt it was especially his duty, as President, to move that they pass in silence a vote of thanks to their Past-President's son, Mr. Hugh F. Boyd, for his kindness in contributing, and to Mr. Robert F. Boyd for reading, this memoir. With these few words he would do his duty best by simply putting the motion, after it had been seconded, for the meeting to pass in silence with a full show of hands.

Mr. G. B. FORSTER said he was privileged in being allowed to second the vote of thanks. He was sure, of all people in the district, the Mining Institute owed perhaps more to Mr. Boyd than anyone else; and, whether they considered his connection with this Institute and with the College of Science, his efforts to advance the education of both professional men and, as his memoir said, of those under him, or his integrity and worth, his diligence and skill in his professional, or geniality and amiability in his private character, he thought they might well say they would be a long time before they would look upon another like him.

The PRESIDENT—Gentlemen, you will kindly show, by holding up your hands, that this vote is fully and unanimously acquiesced in.

The vote of thanks was carried in silence.

Mr. WM. COCHRANE submitted the following "Obituary Notice of the late M. Théophile Guibal":—

OBITUARY NOTICE OF THE LATE M. THÉOPHILE GUIBAL.

BY W. COCHRANE.

Théophile Guibal was born at Toulouse on the 31st May, 1814. At 19 years of age, after private tuition, he was attracted by the reputation of the Ecole Centrale des Arts et Manufactures de Paris to resort to it for the purpose of a scientific education. He entered in October, 1833, and passed the three years' course with considerable distinction, developing his inventive genius, even at this early age, in a remarkable degree, his principal bent being towards mechanical appliances for mining purposes. As an illustration may be mentioned the study which gained for him his diploma of mechanical engineer. In this he worked out the use of two long spear rods, like the so-called "man-engines" of the Cornish mines, for the delivery of coal up a shaft, baskets which were in use at that date being automatically attached and detached at the end of each stroke of the engine, similarly to the progress of a miner up or down, with the result of delivering a full bucket at the top and an empty one at the bottom for each stroke.

His first practical work was in the service of Eugéne Flachat, a leading French mining engineer, under whom he assisted to carry out various mechanical engineering works.

In October, 1837, the project of a School of Mines in the province du Hainaut, Belgium, was started, the chief professorial chair of which seemed to M. Guibal to satisfy his ambition to have a large field of study in every department relating to the working of mines. His application for the post, backed by the reputation he had acquired, was successful, and he settled at Mons to carry out the duties he had undertaken. His teachings and his investigations covered the whole range of mining experience. He had a marvellous facility for imparting information, as is gratefully acknowledged by those who were in his classes, and is known to some of the members of this Institute, who had the privilege in later years of knowing him and deriving the benefit of his varied knowledge. His original works for the improvement of mining science are also of world-wide reputation. Among these was the sinking through water-bearing strata at a great depth where pumping power was inapplicable. An interesting description of this will be found in a biographical notice in the "Publications de la Société des Ingénièurs du Hainaut," a copy of which is in the library of this Institute. It will be seen with what fertile resource and determination he met the many difficulties which were encountered.

Another, perhaps the most important, of his works to which much of his life was devoted, was the improvement of machinery for the ventilation of mines. His system of ventilation is so well known to this Institute, and is so fully discussed in the Transactions, that it need only be referred to. The introduction of it into this country, about 1863, gave an impetus to the investigation of mechanical ventilation, which it may be said has led to the adoption of machine ventilators in almost all important collieries.

Prior to 1863, the earliest reference to mechanical ventilators in the Transactions is in Vol. III., by J. J. Atkinson, in the year 1854–5, and the earliest application recorded in your Transactions in this country was by the same author in Vol. XI.. that of Elsecar and Tursdale Colliery, on the "Biram" principle. The useful effect

was given as 12·69 per cent. The Guibal form was first adapted to the Tursdale Fan in 1863, and subsequently in its entirety at Elswick Colliery. The results are embodied in Vol. XIV., in the year 1864–5.

So decided an advance was established in the useful effect of centrifugal action ventilators that, since then, it has been largely adopted, and it may, without fear of challenge, be asserted that it has established the supremacy of centrifugal action against all others for the purpose of mine ventilation. It was in view of this important invention that you elected M. Guibal an honorary member of this Institute in April, 1870. The Académie Française awarded him for the same work the prize for the most important invention of his time for the health of miners. He died 16th September, 1888.

The School of Mines in Hainaut has decided to erect some monument to his memory and in lasting recognition of his life's work, which they consider has so largely benefited the mining world. This opinion is already confirmed by other countries than Belgium, which was only the country of his adoption, and you are invited to support this object, which will only be a confirmation of the honour to the Institute of having such a man enrolled upon your list of honorary members.

Mr. COCHRANE said, he had not had time to give all the details, but there was a complete French memoir in the library which any member could refer to who wanted to know the particulars of the very difficult works that, as a young man entering his profession, Mons. Guibal encountered,

The School of Mines at Hainaut had decided to erect some monument to him. The Council of this Institute had considered the matter, and he understood the members would be asked to-day to confirm a contribution from the fund of the Institute to assist in raising that monument, which was to be considered international. M. Guibal was not a Belgian, though that was the country of his adoption, and France, where he was born, Germany, and Belgium itself were combining to put their names on such a monument as would be raised to his memory, that it might be shown that the work he did was universally approved, and that he was in his time a most important contributor of mechanical appliances to the development of the mining industry.

The PRESIDENT—The Secretary will read the minute of the Council.

Professor LEBOUR read the following :—

Memorial to the late Professor Guibal.—On the motion of Mr. Douglas, seconded by Mr. W. Armstrong, Jun., that the sum of £25 be subscribed to the Guibal Memorial Fund now being formed in Belgium; and Mr. Cochrane undertook the correspondence on this subject with the manager of this fund.—*Minute of Council, 30th November, 1889.*

Mr. A. L. STEAVENSON regretted that he had not been able to hear the paper read, but from his knowledge of the fan invented by M. Guibal and his different works as an engineer, he (Mr. Steavenson) was sure that whatever Mr. Cochrane had said was well deserved. He was a man belonging to no nation, but to every country, and his discoveries were invaluable to the whole world. He (Mr. Steavenson) had pleasure in proposing a vote of thanks to Mr. Cochrane for writing the memoir.

Mr. M. WALTON BROWN seconded.

The PRESIDENT said he cordially agreed with Mr. Steavenson's remarks, and put the motion to the meeting. It was unanimously adopted.

Mr. COCHRANE, in thanking the meeting for the vote of thanks, said he was glad to find that what little he had written was corroborated by Mr. Steavenson's remarks. What M. Guibal did in his life was of world-wide importance. He hoped he would have the pleasure of communicating to Mons. Briart the confirmation of the Council's recommendation.

The CHAIRMAN put the recommendation of the Council to the meeting, and it was unanimously confirmed.

Mr. COCHRANE said he would communicate to Mons. Briart the vote of the Institute, and also their reception of the memoir.

The PRESIDENT stated that, owing to the absence of Mr. Bayldon, that gentleman's paper on "The Houraki Mining District (Northern Section), Auckland, New Zealand," would be read at the next meeting.

The following paper by Messrs. T. E. Forster and H. Ayton on "Improved Coal Screening and Cleaning" was read:—

IMPROVED COAL SCREENING AND CLEANING.

By T. E. Forster and H. Ayton.

Perhaps in no department of above-ground colliery plant has a greater change taken place during the past few years than in that which appertains to the treatment of the coal after reaching the surface.

The introduction of mechanical means for screening and cleaning coal is now taking place on so extensive a scale, and has been proved to be so economical and efficient, that the old-fashioned fixed screens, with their heavy charges for the labour required for screening, cleaning, and banking out, with in many cases comparatively unsatisfactory results, are being rapidly superseded in most parts of the country by the introduction of machinery to do their work.

Although various systems of mechanically treating coal have been applied for a considerable number of years, they appear only to have been utilised in isolated cases until the evolution of the travelling picking table or belt, generally in combination with the vibrating screen, drew attention to the economy and advantages to be gained by the application of this particular system.

Its success is, no doubt, due to the very much greater ease and economy with which coal, and more especially that from either mixed seams or those which contain a very high proportion of refuse or inferior coal, can be treated as well as to the reduction in the amount of breakage which takes place, and the consequently improved state of the coal when ready for market. In addition to this, it may, perhaps, to a certain extent be accounted for by the, comparatively speaking, low cost of installation, and the ready adaptability of the system to existing heapsteads, and to places where it is impossible to make any great alteration in the structural arrangements and general disposition of affairs.

There is also, no doubt, a considerable advantage to be derived from the ease with which the banking-out operations can be performed, especially in the case of large outputs and the saving which may in consequence be effected under this head, not to mention the greater facility with which the small coal can be collected for further manipulation where it is so required.

The general arrangement of a screening and cleaning plant of the above nature varies to so great an extent with the quantity to be treated, the nature and amount of the refuse to be separated, and the specific purpose for which the coal is to be subsequently marketed, in addition to the local requirements of each individual colliery, that it may perhaps be more expedient to describe certain details and arrangements, suitable for general purposes, before offering any remarks as to the main principles and points to be taken into consideration in laying out a plant for any definite purpose.

Motive Power.

The position of the engines used to drive an apparatus is frequently a matter of some consideration. It is, of course, advisable to place the engine as near as possible to its work, and to complicate the gearing to as small a degree as possible. At one time it was considered to be a great advantage to drive the belts from the leading end, but except, perhaps, in the case of very long and heavily loaded belts (where a separate engine is frequently employed), it is now more usual to find the driving power applied at the back end, owing to the fact that it is usually the most convenient point and being close to the screens, allows a large amount of shafting to be dispensed with.

In cases where there is very little variation in the nature and class of the coal produced, and the amount of separation which is required, it is generally found sufficient to drive both belts and screens from the same engine, as under such circumstances it is highly improbable that any variation between the ratio of the screen and belt speeds will be required.

In some instances, however, it may happen to be necessary to alter the relative speeds, either frequently or at intervals, and it is therefore preferable to employ an independent engine to actuate the screens. Cases such as these may occur where there is a great variation in the nature of the produce of different parts or seams of a colliery, in the relative proportions of coal which is to be passed over the belt at any time, as, for instance, in the case of a plant making unscreened coal at frequent and irregular intervals when the belt speed requires to be increased to thin the coals down to a proper degree for easy picking, and the screens, if fitted with dumb plates, require to be slowed down.

It is, furthermore, at times a matter of great difficulty to estimate the correct speeds in the case of unopened seams or collieries, although such difficulties may be to some extent guarded against by arrangements for regulating the feed and length of stroke of screens.

Fig. 1, Plate II., represents an arrangement which was applied to an apparatus sent to the New South Wales coal-field, with the view of enabling the engines either to be run as a pair working the entire plant or to be disconnected and used independently. The left-hand engine can be employed to drive the belts and the right-hand one the screens, or the two can be coupled by means of a coupling between the cranks. Each cylinder also is made sufficiently large to drive the whole plant in case of accident to the other so as to avoid any long stoppage.

It is also a matter of some consequence where engines and machinery are placed on a heapstead, as frequently occurs, to pay some regard to the general construction and balancing of the machinery, so as to minimise, as far as possible, the vibration which is often unavoidable without having to employ an unnecessary amount of material on the erection which carries it.

Screens.

These may be divided into two classes, viz., the main screens, on to which the whole produce of the colliery is passed, and secondary screens for the treatment of the smaller classes of coal.

Main screens. The amount of fall required on a vibrating screen varies, of course, with the nature of the coal, and also to a smaller degree with that of the screen itself and its speed and throw. Approximately speaking, a fall of about 3 to 3½ inches per foot, or an angle of 14-15 degs., will be found suitable for most classes of coal in this district, the necessary angle (other things being equal) being slightly less for bars or locket-work screens than for square wire gauze or "sectional" locket-work.

The simplest form of screen is a tray containing the gauze suspended on short vibrating arms carried from the fixed sides of the screen frame. (Fig. 6*a*, Plate III.) In some instances a dumb tray is added underneath for the collection of the small, where it is required for further treatment, and where a hopper cannot advantageously be placed. (See A, Fig. 15, Plate IV.) In other cases the whole body of the screen is slung from above and subjected to the jigging motion, the screening surface being fixed inside it, with a flat hopper underneath to deliver the small at one point. (Fig. 2, Plate I.) This entails the movement of an extra amount of weight, and is consequently only suitable for screens of ordinary dimensions; but, on the other hand, it is possible to arrange a screen of this description so that the angle may be

varied without much difficulty or delay. Where two or more screens are in use, and worked from the same shaft, the eccentrics are set so that a balance is effected by the simultaneous opposite movements of the screens; and where unusually long screens are required, it is better to cut them so as to form two consecutive screens, each driven by its own eccentrics and balanced as above. (Fig. 21, Plate VIII.)

Provision is also desirable, where screens are in duplicate, for throwing either out of gear, and for varying the length of throw, which is usually done by variable eccentrics (Fig. 16, Plate II.) or otherwise.

The width and length of the screening surface depends on the quantity of small to be extracted, the condition of the coals, and, where the screen is not fed by a regulator, on the size of tub which is used.

The general width is from 4 to 5 feet or more, and in most cases a gauze of 8 to 10 feet in length is found sufficient.

The most important point to be watched is the passage of the coals on to the screening gauze in a regular and even layer, so that the whole of the small may be eliminated. Where coals are allowed to rush forward on to the gauze in a heap a longer gauze is required, and perfect separation becomes a matter of difficulty or chance. This may, however, be ensured by the employment of a fixed shoot at the head of the screen, on to which the coals are tipped, passing gently forwards on to the gauze, which is in consequence preserved from undue wear and tear. The addition of a regulating trap above the gauze is further, and more especially for rapid teaming, a great advantage; and where the space at disposal does not allow of a sufficient length of shoot a "spreader" (B, Fig. 15, Plate IV.), consisting of a plate slightly hollowed in the middle so as to prevent the coals sliding forward in a mass, and fixed immediately above the gauze, with which it vibrates, is perhaps as efficient, and requires no attention.

The material of which the screening surface is composed is usually either—

1. Steel bars, made as light and as deep as is possible in order to ensure the clearance of the small, and occasionally plates with openings arranged on different plans. These are, however, somewhat heavy, and the actual amount of surface open for the passage of small is less in comparison than with steel or wire gauzes, which are commonly preferred.

2. Square wire gauze. (Fig. 3, Plate II.) This has the advantage of lightness and cheap first cost, and appears to be most commonly employed. Where the coal contains long thin or "shivy" pieces, they can be passed over without dropping into the small, as sometimes happens with bars or locket-work. This is frequently of importance where stones of the above nature are present, and the small coal receives no further treatment.

With large and heavy coals there is sometimes a tendency for the cross wires to spread, which can, however, be to some extent obviated by using a double crimped wire gauze, or by increasing the gauge of the wires.

3. Locket-work. (Fig. 4, Plate II.) This is formed of continuous wires running the full length of the gauze, and turned at intervals (generally of 4½ to 5 inches) over round iron bars. It presents a smoother surface, and is self-supporting, requiring no stretching-frame, as in the case of square wire gauze. The first cost is higher than the latter; but it is sometimes preferred as showing little or no tendency to lose its gauge. The thickness of the wire used is dependent to some extent on the gauge of the screen, a certain number of turns on the bar having to fit with the open spaces between the wires.

4. Sectional locket-work. (Fig. 5, Plate II.) This form of locket-work has been introduced with the object of facilitating any repairs which may be required. It is constructed so that the section between every two bars is formed of an independent

wire, and can be removed and replaced by a fresh section. The wire is twisted round the two bars, alternately passing from the bottom of one to the top of the other, and *vice versâ*, as shown. This destroys the smooth surface, and forms a number of lodgments in which small pieces of coal are apt to catch, and so tends to destroy the efficiency of the screen.

The relative duration of the different forms of wire gauzes is a subject on which it is difficult to obtain reliable information, but as far as can be gathered the cost of repairs and renewals to the screening surface is less than in the case of fixed screen bars.

The following shows the different gauges of the wires which are usually employed for screen gauzes, with the approximate cost per square foot.

Size of Mesh.	Square Gauze.		Locket-Work.		
	B.W.G. of Wire.	Approximate Cost per Square Foot.	B.W.G. of Wire.	No. of Turns on Bar between Wires.	Approximate Cost per Square Foot.
Inch.	No.	s. d.	No.	No.	s. d.
$\frac{3}{16}$	13	1 6	...	...	...
$\frac{1}{4}$	11	1 9	...	...	...
$\frac{5}{16}$	11	1 6	...	...	...
$\frac{3}{8}$	9	2 0	...	...	...
$\frac{1}{2}$	9	1 9	3	2	3 6
$\frac{9}{16}$	...	...	2	2	4 0
$\frac{5}{8}$	9	1 6	1	2	4 0
$\frac{3}{4}$	4	1 9	00	2	5 0
1	3	1 9	0	3	4 6
$1\frac{1}{8}$	4	1 6	00	3	5 0
$1\frac{1}{4}$	1	1 6	1	4	4 0
$1\frac{1}{2}$	0	1 9	...	...	...

Locket-work bars usually $\frac{1}{2}$ inch to $\frac{3}{4}$ inch diameter and $4\frac{1}{2}$ inch centres, leaving about 3 inches clear space. Prices are for complete gauzes, ready for screens of ordinary sizes.

The speed and throw of screens vary inversely, and are also dependent on the nature of the coal and fall of the screen. From 90 to 110 vibrations may be taken as a very usual speed, with a throw of about 5 inches.

Secondary Screens.

The general form of nut screen is a reproduction of the main jigging screen, and fitted as a rule with square wire gauze.

The manufacture of more than one class of coal on it, either by employing a long screen having the necessary number of gauzes of different mesh and separated by short plates (Fig. 21, Plate VIII.), or by placing the gauzes in succession, one above the other. (Fig. 17, Plate V.) The latter plan is perhaps hardly so well adapted to most classes of coal, and is not so generally in use as the former by which the passage of the coals over the whole length of each gauze is secured.

When working with a small mesh it is frequently found that the clogging of the gauze by wet coal is a serious defect, so much so that at some collieries arrangements are made to keep this coal out of the nut screens altogether, and in some places revolving nut screens are used as exhibiting a tendency to clog in a lessened degree.

It is, of course, desirable to feed the nut screens if possible by gravitation from the main screens, but where re-elevation is necessary the employment of elevating belts where possible will generally be found to be an improvement on the old form of bucket elevator. The belt elevator delivers the small in a more regular and con-

tinuous stream, and with a smaller amount of wear and tear. For elevating small coal, angle or bucket plates may be attached to the plates at intervals, the depth and number being proportioned to the load and speed of the belt.

Fig. 6, Plate III., is an illustration of the method in use at Ashington Colliery, the elevators taking the small direct from the main screen to the nut screen, which is placed immediately behind and in the same line. A trap is here provided at *b* for separating any wet coal from the small.

Where there is sufficient height at disposal a nut screen placed immediately under the main screen, either in the same line or at right angles to it, is a ready and economical arrangement, but it is better where room is small to re-elevate rather than run the chance of inferior screening due to insufficient space.

BELTS.

There is, comparatively speaking, but little difference in the general design and construction of belts in use at the present time. The form which is almost universally in use consisting of steel plates attached to endless chains composed of links usually 12 to 14 inches (centres) in length, the chief dissimilarities resting in the form and materials of the links, and the methods of attaching the plates to them.

A variety of designs have been in use from time to time, such as flat hemp or wire ropes, wire gauze, chains, and plates on wire ropes, but these have in most cases given place to the above-named generally adopted pattern. Plates bent so as to pass round a circular tumbler and others of a corrugated form have also been tried, but apparently with a similar result.

The chain links are generally either jaw links (usually cast steel) (Fig. 7, Plate I.) with a projecting bracket for the attachment of the plate, or double and single links (wrought iron or steel). (Figs. 8, 9, and 10, Plate I.)

The former constitute a lighter chain, but are not so easily repaired as the latter which are occasionally made with a swelling at the ends so as to ensure longer wear. The plates are attached to single and double chains, either by riveting through the single links and to short pieces of angle iron which are again riveted to the side of the double links, or the angles may be dispensed with and the double link swelled near the end to admit a direct rivet. (Fig. 8, Plate I.) It is, however, an undoubted advantage to be able to substitute a plate without cutting any rivets, and with this object in view the attachment is made either by riveting the plates to angle irons, which are bolted to the links (Fig. 9, Plate I.), or by hook bolts which grip the link through a hole in the side and are secured by a nut above the plate. (Fig. 10, Plate I.)

The chains are usually carried on rollers placed at intervals of about 2 feet 6 inches apart on the upper or loaded side, and double that distance on the return side. The abolition of rollers and substitution of slides is a practice which has recently obtained to some extent, belts of 200 feet and upwards being in operation on this principle. It is, however, difficult to suppose that as far as power and durability are concerned there can be any advantage although the first cost is lessened. The tendency to sag, which roller belts often have, unless fitted with rollers at very frequent intervals is sometimes objectionable, and may be obviated by carrying the plate ends on angle irons, which also serve to confine the coals to the belt. (Fig. 11. Plate I.) For belts up to 60 or 70 feet long and 4 feet wide, carrying an ordinary load, two chains are sufficient, but with a greater width or length a treble chain is used. The tumblers should be kept as small as possible at the leading end in order to reduce the fall over the belt end into the shoot. For long and heavy belts the driving tumblers should be fitted with projecting jaws, but for smaller sizes this is unnecessary. A sliding tightener should be provided for the trailing end, although this is sometimes dispensed with on short belts.

The main points to be considered in determining the length, breadth, and speed of the belting are the amount of the load, the nature of the coal, and the nature and proportion of the stone or coal requiring separation.

The speed is governed by the fact that, if increased beyond certain limits, it becomes more difficult to ensure perfect cleaning, except at the cost of unnecessary extension of the belt, and if decreased, the heaping of the coals upon the belt becomes a serious evil. It is of the highest importance that the belts should only be loaded with coals sufficient to form a tolerably thin layer so that the refuse can be easily detected, and over-loading belts should be carefully avoided. The most suitable speed for picking appears to be about 50 feet a minute, and above this it is doubtful whether, except, perhaps, in some special cases, the thinner layer obtained by the extra speed counterbalances the greater difficulty in picking, especially where chipping is requisite. Irrespective of speed the length is governed by the amount and nature of the refuse.

For an average coal containing anything up to 4 per cent. of refuse on the total load it will generally be found sufficient to provide 45 to 50 feet of belting for a load of 300–350 tons to be passed over the belt in ten hours at a belt speed of 50 feet per minute, the width of belt being 4 feet, but where much chipping has to be done in addition it is better to extend the length to 60 or 70 feet. At higher speeds, or with a heavier percentage for separation, belts up to 100 feet and even more are necessary. It is always, however, best to err on the safe side and allow a considerable margin in view of any unforeseen contingency. The width (where there is no middle division for stones) is usually 4 feet, and from this to 4 feet 6 inches will be found the most convenient. Five feet belts are occasionally used, but it is a question whether the increased amount of space obtained compensates for the greater distance the pickers (especially in the case of boys) have to reach. The most convenient height is about 2 feet 6 inches.

In laying out a plant it is always advisable to duplicate as far as practicable, and although it may be possible to run a large quantity on to a screen and over a belt at a quick speed, it will be found a much safer course, as a rule, to work with two screens and shorter belts at slower speeds. The latter plan has the additional advantage of enabling either screen and belt to be worked independently in case of need, and at a higher speed so as to avoid any loss of time should any break-down happen to the other. There is always a possibility, reduced it is true by careful inspection and attention to a very slight one, of a stoppage where machinery is used, and it is, generally speaking, a satisfaction to minimise the chance, as far as can reasonably be done, without any heavy increase in the first cost.

It is sometimes requisite to gain additional elevation at the delivery end, and this can be done by placing the belt at the requisite angle, which is limited by the sliding power of the coal. The greatest angle which has been employed (without special appliances) being, it is believed, about 4½ inches to the foot.

Loading Shoots.

The loading of the coal from the belt into the trucks is performed by a shoot placed as close to the tumbler as possible, and slightly below the line of the tumbler shaft, Several schemes have been devised for minimising the fall from the belt on to the shoots, none of which appear to be particularly successful in practice. Careful adjustment of the shoot and a small tumbler is perhaps the best and simplest plan. The fall from the fixed shoot end into the empty truck, and consequent breakage, can be to a great extent avoided either by a short shoot hinged to the end of the fixed one, and counterbalanced, or, better, by a telescopic plate (see C, Fig. 15, Plate

IV.), which may be run out towards the bottom of the empty truck and drawn up gradually as it is filled. The very objectionable drop which takes place from fixed screens is thus done away with, and rapid loading facilitated.

The above remarks refer generally to the nature and construction of the various parts, many or all of which are required in every apparatus.

It will now be necessary to make some observations as to the different methods in which they may be arranged, so as to form a plant which is most likely to be suitable for any given purpose.

The subject may be considered under two main heads, viz., (1) where the screening precedes the cleaning, and (2) where the coal is first cleaned with or without subsequent screening.

The first is by far the most usual system employed, and will be found to be the best in the case of collieries where the output is, as a general rule, classified, and where no large proportion of unscreened coal is made.

In many cases the quality of the small coal is sufficiently good to enable it to be marketed without further treatment; but when picking is required, it is perhaps more easily and economically effected on a separate belt, where it is free from the larger coals, and the small stones can be more easily detected.

Where the proportion of unscreened to be made is large, it is sometimes found better to tip the coals directly on to the belt, and place the screen at the leading end, arranged in such a way that the unscreened may be loaded direct into the trucks without passing over the screens. Unscreened is always more difficult to clean, especially when the coal is particularly uneven in size. Under any circumstances, however, an extra area of belt space is most desirable for this class of coal, so that it may be run down to a much thinner layer than is otherwise necessary. At some works where only one class of coal is made, and the best results desired, a series of short belts are used in preference to one of considerable length, in order that any one may be stopped, should the coal be specially dirty, without undue interference with the remainder of the work. The short belts either deliver direct into wagons or on to a main collecting belt, running at right angles to them, and into a loading shoot in the usual way, or on to screens as an alternative.

When small quantities of unscreened coal are required at irregular intervals and short notice it is sometimes best to employ a dumb spout feeding directly on to the belt. This is generally practicable when the screens are at right angles to the belts, the only disadvantage being that it occupies a certain amount of belt space. With screens and belts in a line the difficulty is greater, and is usually surmounted by fixing a plate over the gauze. In this case, unless the screen speed can be slowed down, it is necessary to supply some device in order to prevent the coal sliding down in a heap on to the belt; and for this purpose an angle iron may be fixed at the foot of the dumb plate, or the plate end bent slightly upward, so as to retard to some degree the passage of the coals in a body. There is also a certain amount of time wasted in altering the screen, especially when frequent changes are unavoidable, and to obviate this difficulty arrangements may be made to remix the best and small by means of a trap at the screen foot. This method is adopted at Cowpen Mill Pit, but can only be utilised when the screen is fitted with a double tray. (D, Fig. 15, Plate IV.) It has the advantage, where the belt is not fully loaded, of keeping the two sizes partly separate on it, and allowing them to be more easily cleaned.

Fig. 12, Plate VI., represents a device which is employed at the St. Hilda Colliery for plating the gauze with as little delay as possible, and consists of a plate which can be raised or lowered at will by means of levers actuated by a worm and spur wheel.

Disposal of Pickings.

The method of disposing of the different kinds of refuse or coal which may be picked off the belts requires some notice. The most usual custom is to throw the pickings on to benches or hoppers at either side of the belts, from whence they can be collected by means of shoots into wagons, or reloaded on to the belts and into wagons as opportunity offers. The question is, of course, largely dependent on the amount and number of classes of coal or refuse which are separated, and on the general arrangements and facilities which prevail at each individual colliery.

The addition of a stone partition in the middle of the belt (A, Fig. 9, Plate I.) has been largely adopted recently, and is perhaps best suited to places where only a single class is picked, such as stones or other small refuse, and where the delivery can be effected without any interference with the loading shoots. The adoption of this method, of course, necessitates an increase in the width, and consequently in the weight and cost of the belt, but on the other hand the space occupied by and the cost of erecting benches is reduced. Where considerable quantities are picked off and separated into different classes it has been suggested that a collecting belt placed at a lower level and fed from a series of hoppers, into which the different classes of coal and refuse can be thrown, might be employed as an economical substitute for the ordinary bench deposit, and could be arranged to load each class at intervals direct into wagons at either end.

Laying out Tubs.

The difficulties which were at one time anticipated with regard to the laid out tubs under this system have been found in practice to be very slight. The custom usually is to station a man at the foot or side of the screen who can readily detect an undue quantity of refuse in the coal from any tub, and on suspecting one he places a mark or token at each end of the space occupied by its contents on the belt. Boxes are then placed on the belt and the refuse collected for weighing. Any ordinary amount of laid out tubs can easily be dealt with in this way, cases having occurred where as many as 150 tubs have been so treated in a day of ten hours on a single belt.

Design.

The particular design of a plant most suitable for a given purpose is dependent to a great extent on the local circumstances and conditions which are peculiar to each individual colliery, and in the case of substitution for obsolete methods is largely governed by the buildings which are already erected and which may in most cases be utilised. It is, perhaps, preferable to arrange screens and main belts in one line if practicable where double screening is used without re-elevation, as this allows the different classes of small to be more easily loaded on to separate roads by means of cross belts of different lengths. For single screening the arrangement of placing the belts at right angles to the screens is most suitable, and can generally be most easily adapted to buildings previously occupied by a range of fixed screens. It is in this case perhaps better where duplicate belts are being erected to run them in different directions in line with one another, and loading from their respective ends by curved shoots. This prevents one screen having to be made unusually long as occurs where the belts are placed side by side.

It appears desirable in order to illustrate more clearly the various arrangements which may be used and are more adapted to the requirements of different classes of coal, to give a description of several existing designs, and for that purpose the following examples may be taken.

Mill Pit, Blyth. (Figs. 13, 14, and 15, Plate IV.)—This apparatus is designed for the treatment of an average quantity of 1,000 tons in ten hours, with a maximum of 1,200 tons.

The coal after being tipped from a 12 cwt. tub on to either of the two screens furnished at the top with a curved spreading plate, and each carrying ½ inch locket-work gauzes 10 feet long by 5 feet wide, is separated into best and small, a certain proportion of the latter being sub-divided into nuts and duff, and provision being made for cleaning the round coal and nuts, and for keeping separate the entire produce of either of the two screens and belts.

The screens lie at an angle of 15 degs., and are run at 100 vibrations per minute. They are driven direct from an independent single horizontal engine, 10 inches by 16 inches, placed immediately behind by means of variable eccentrics having a throw of from 5 inches to 6½ inches. The round coal is delivered by shoots on to the main picking belts, and the small is collected by means of vibrating dumb trays attached underneath the gauzes with traps for the disposal of the small in the following ways:—The two higher traps (E, F, Fig. 15, Plate IV.) when open allow the small to drop into a hopper (H) placed underneath, whence it can be loaded on to the best coal roads. The third (G) deposits the small on to the cross belt (A, Fig. 14, Plate IV.) for elevation to the nut riddles, or for loading by means of a separate shoot (B, Fig. 14, Plate IV.) on to a separate way. By closing this trap the small passes down a shoot (D, Fig. 15, Plate IV.) underneath the best coal spout, and is remixed on the belt to form unscreened.

The belts are two in number, each 70 feet centres by 4 feet wide, and are placed in line with the screens. They are driven from the back tumblers by shafting and spur gearing from the main engines (12 inches by 24 inches) (A, Fig. 13, Plate IV.) which are placed near the screen engine, both being separated from the screening and picking shed by a partition. The belt speed is 45 feet per minute with the engine running 96 strokes. Both belts are fitted with clutches at the back end. The loading spouts deliver on to two parallel rods and are fitted with telescopic shoots, 5 feet 6 inches by 4 feet wide, which are counter-balanced. (C, Fig. 15, Plate IV.)

The weigh tables are placed immediately beneath the shoots, and are occupied by the wagons during filling in order that the extra labour employed at an adjusting bench, which would be otherwise required in loading to a standard weight, may be avoided, and also to enable the tare to be taken if desired. The steelyards are placed on the platform level.

The percentage of round coal is about 75, out of which about 2½ per cent. is picked in the form of stones and brasses, in addition to 2 per cent. of second class coal.

The cross elevating belt is 3 feet 6 inches wide by 45 feet centres, rising at an angle of 23 degs., and having 2½ inch angle irons attached to the plate at intervals of 7 feet, the whole being carried on a lattice framing. It is driven from the top end by a horizontal shaft connected to the main engine, and runs at a belt speed of 45 feet per minute. The elevator delivers either into the small coal shoot or by means of a breeches spout (C, Fig. 14, Plate IV.) into the two revolving nut screens, 4 feet diameter, fitted with a square mesh gauze, 9 feet long. They lie at an angle of 18 degs., and are driven by bevel gearing on a counter shaft worked by a belt from the horizontal shaft above-mentioned. The duff is delivered into a hopper common to both, and the nuts, from which about 2½ per cent. of refuse is picked, on to a belt 35 feet long, and similar to the main belts in all other respects.

St. Hilda Colliery. (Figs. 17 and 18, Plate V.)—This plant is intended for the division of the coal treated into a considerable number of classes suitable for house-

hold, gas, and manufacturing purposes, and is a good instance of the facility with which the frequent changes and combinations required under these conditions may be effected with economy both of time and labour.

The coal is of such a nature as to allow of its sub-division by means of screen gauzes placed in succession immediately below one another, and carried on the same locking arms.

It is first tipped (by means of revolving kick-ups driven from screen shafting) into hoppers (*a*, Fig. 17, Plate V.) fitted with regulating feed traps, and thence passes on to the main screen gauzes. Each of these is 10 feet by 4 feet, with 1¼ inch square mesh lying at an angle of 15 degs. and delivering the round coal direct on to a picking belt. The two belts are each 48 feet long and 4 feet 10 inches wide, including a 10 inch middle division for stones, and are speeded to run at about 55 feet a minute.

The coal passing through the top gauze falls on to the nut screen, 9 feet by 4 feet and ⅝ inch square mesh, the nuts being delivered on to a small cross belt (*b*, Fig. 18, Plate V.)—12 inches wide, and running 90 feet a minute—which conveys them to a 4 feet (*c*, Fig. 18, Plate V.) picking belt parallel to the main belts, and having its trailing tumbler depressed so as to permit delivery from the cross carrying belt.

The third gauze converts the remaining coal into peas, which are loaded by a small jigging tray into wagons, and duff, which falls into a hopper placed immediately beneath.

For the manufacture of unscreened a lowering plate similar to that noticed above (Fig. 12, Plate VI.) is provided, and by means of a well-arranged series of traps the nuts and peas can be remixed and loaded as one class of small (best household) the peas and duff as another (factory), or, if desired, the three descriptions can be recombined.

Both belts and screens are driven by an engine having a pair of 12 inch by 16 inch cylinders. The screens are worked by connecting rods from slotted adjusting discs (*d*, Fig. 17, Plate V.) fitted to counter shafts and driven by 18 inch spur gearing at equal speeds with the main screen shaft, each screen being supplied with friction clutches. The screen speed is 100 strokes per minute, and the produce, with a 6 inch throw, is:—Best coal, 37¼ per cent.; nuts, 28¼ per cent.; peas, 25½ per cent.; and duff, 8¾ per cent.

The picking belts are all driven from the leading end, and are clutched there, the power being transmitted by shafting and bevel gear. The loading shoots are constructed with hinged reversing plates at the top (*e*, Fig. 17, Plate V.) and double spouts, so as to allow the coal to be loaded on to either of two parallel roads at will.

The coal is drawn and tipped at two levels, one screen and belt being reserved for each level: the gross quantity which the apparatus is capable of treating being 750 tons to each level, or 1,500 tons in all, in 10 hours, the amount of refuse picked out being about 2 per cent. of the gross quantity.

Beamish Colliery. (Figs. 19 and 20, Plate VII.)—The difference in the general design of this apparatus from that of those already described is due to the fact that it is intended for the cleaning of a coal containing a considerable proportion of small refuse, which it is equally important to eliminate from all the classes into which it may subsequently be divided.

To ensure this object the cleaning is done on four short belts (*a*, Fig. 19, Plate VII.) prior to screening, the produce of the picking belts being conveyed by means of a cross carrying belt (*b*, Fig. 19, Plate VII.) to the screens for further treatment.

After being deposited in hoppers (*a*, Fig. 20, Plate VII.) the coal is fed on to each belt by a trap, with a small roller at the outfall (*b*, Fig. 20, Plate VII.) to ensure a regular and even distribution. Each belt is 35 feet in length and 4 feet 10 inches

wide, including a 10 inch stone division, and travels at a speed of about 50 feet per minute. They are driven from the leading ends and are fitted with friction clutches, so that any belt may be thrown out of gear without any stoppage of work on the others. The stones are discharged into hoppers, from which they can be dropped into wagons for removal. The delivery of the coals is on to a cross belt 35 feet long by 5 feet wide, which conveys the coal to a screen (*c*, Fig. 20, Plate VII.) placed at one end and parallel to the picking belts. The main screen is fitted with cast iron plates, having diagonal openings varying in size according to the class of coal to be made, and an underneath tray for the collection and delivery of the small —directly, if required—on to a nut screen (*d*, Fig. 20, Plate VII.) placed immediately below, with a hopper for delivery of duff. The speed of both screens is about 70 vibrations per minute, with a 7 inch throw and an angle of 16 degs.

The whole of the machinery is driven by shafting from a 12 inch by 24 inch engine placed at one end, and is arranged with a view to being subsequently duplicated for separate treatment of the produce of two shafts, so that the number of picking belts employed for each pit may be easily varied with the fluctuations of the outputs by altering the respective lengths of the cross carrying belts.

That part of the plant of which a sketch is given is capable of treating a gross output of 900 tons in 10 hours.

With the elimination of the cross belts and screens the design is similar to that most frequently adopted at collieries treating entirely unscreened coal.

Some mention of the system of picking and loading large coal into trucks by hand, which is common in the Midlands, may perhaps be of interest.

Under this system the most improved method seems to consist in cleaning and picking the coal on a belt placed at such a level that the large coal can be easily loaded by hand into trucks standing on roads placed on either side of and parallel to the belt.

The coal is tipped direct on to the belt, which may be 100 to 200 feet in length according to circumstances, and after cleaning and hand-picking, the residue is raised by a belt elevator (Fig. 22, Plate VIII.) to a level sufficient to allow of its separation by screening into (usually) three sizes, viz.:—cobbles, nut, and slack.

The screen (*a*, Figs. 21 and 22, Plate VIII.) is placed at right angles to the belt, having gauzes of different mesh, and delivering the different classes made on to separate ways.

The size of screen and length of gauzes is, of course, proportioned to the quantity of coal which remains after picking has taken place. It is in this case shown as a double balanced screen capable of treating about 1,000 tons in eight hours.

COST.

The cost of treating coal on the above described principle compares as a rule very favourably with that under systems hitherto generally adopted. The saving under ordinary circumstances may be estimated at a ½d. to ¾d. per ton on the gross output. This is due mainly to the reduction of manual labour to that required merely for the picking and chipping, which renders possible the employment of boys for a large proportion of the work. At many collieries in the North of England where screeners are supplied with houses and fire-coal, the lower rate of wages paid is still further accentuated.

It must not, however, be supposed that the mere saving of labour is the only advantage to be obtained, as the greater ease and certainty with which the separating and sorting can be performed and the superior class of coal which results are benefits of much more serious importance.

The following table has been prepared from data obtained from various collieries where the system is in operation, and may, perhaps, be of some interest.

TABLE OF COSTS, Etc.

	1	2	3	4	5	6	7	8	9	10	11
Gross quantity treated per day in tons	1,100	950	860	850	800	750	700	600	500	500	240
Net hours worked ..	10	10	10	10	9¾	9½	10½	10	9	9	10
Percentage of (1) Round ..	72·15	61·82	47·60	66·62	unscreened.		55·31	74·8	51·00	53·00	40·00
(2) Small ..	25·93	35·99	43·96	32·22	95·25	94·7	35·47	20·6	41·00	28·50	41·60
(3) Inferior Coal ..	..	1·33	6·21	..	2·00	1·46	8·40	..	5·58	17·50	16·32
(4) Refuse ..	1·92	·86	2·23	1·16	2·75	3·84	·82	4·6	2·42	1·00	2·08
Total percentage picked out ..	1·92	2·19	28·44	1·16	4·75	5·30	9·22	4·6	8·00	18·50	39·40
Total load on belts in tons ..	815	609	747	576	800	750	545	476	295	357	209
Percentage of load picked out ..	2·57	3·44	32·74	1·73	4·75	5·30	11·84	5·8	13·55	25·87	44·00
Screens—No of ..	1	2	1	1	..	..	1	1	1	1	1
Angle ..	15 deg.	15 deg.	17½ deg.	15 deg.	..	..	16 deg.	15 deg.	15 deg.	15 deg.	17½ deg.
Gauzes { Size ..	ft. in. ft. in. 9 4 × 4 8	ft. in. ft. in. 10 6 × 5 5	ft. in. ft. in. 8 0 × 4 0	ft. in. ft. in. 9 4 × 4 8	..	..	ft. in. ft. in. 9 0 × 4 0	ft. in ft. in. 8 0 × 4 6	ft. in. ft. in. 9 4 × 4 8	ft. in. ft. in. 9 4 × 4 8	ft. in. 8 × 4
Gauzes { Description ..	square	locket	square	square			sec. locket	square	square	square	square
Mesh ..	in. in. ⅜ and ¾	in. in. 9-16 and 11-16	in. in. ⅜ to 2 (various)	in. in. ⅜ and ¾	..	..	1 in.	⅜ in.	in. 1	in. 1	in. in. ⅜ to 1½ (various)
Strokes per minute ..	110	70	88	110	..	..	100	96	90	90	88
Stroke, length of ..	5 in.	7 in.	9 in.	5 in.	..	..	8 in.	5 in.	7½ in.	7½ in.	9 in.
Belts—No. of ..	1	2	1	1	8 1	4 2	1	1	1	1	1
Length ..	98 ft.	55 ft.	60 ft.	85 ft.	24½ ft. 60 ft.	17 ft. 51 ft.	80 ft.	108 ft.	100 ft.	100 ft.	34 ft.
Width ..	5 ft.	4 ft.	4 ft.	4 ft.	ft. in. ft. in. 3 4 4 5	4 ft. 9 in. (incl. 9″ stone divisi n)	4 ft. 10 in. (incl. 10″ stone division)	5 ft.	4 ft.	4 ft. 6 in.	4 ft.
Speed in feet per minute ..	55 ft.	50 ft.	87 ft.	55 ft.	40 ft.	75 ft.	80 ft.	58 ft.	53 ft.	53 ft	74 ft.
Nut making—% on Small of (1) Nuts ..	66	76	48	66	..	..	37·55	..	..	..	..
(2) Peas .. } (3) Duff .. }	34	21	52	34	..	..	62·45	..	..	..	..
Screens—No. of ..	1	2 revolving	1	1	..	..	1	..	..	..	..
Angle ..	15 deg.	14 deg.	..	15 deg.	..	..	10 deg.	..	..	..	..
Gauzes, size of	ft. in. ft. in. 14 0 × 4 8	..	ft. in. ft. in. 5 0 × 2 6	ft. in. ft. in. 14 0 × 4 8	..	..	5 ft. × 3 ft.	..	..	..	..
Mesh (square) ..	3/16 in.	¼ in.	1 in.	3-16 in	..	..	⅜ in.	..	..	..	..
Speed ..	110	36 revs.	88	110	..	..	100	..	..	..	..
Stroke ..	5 in.	..	9 in.	5 in.	..	..	8 in.	..	..	..	..
Cleaning Belts— No. of ..	..	1	1	..	..	..	1	..	..	..	..
Length	..	25 ft.	24 ft.	..	..	..	15 ft. 6 in.	..	..	..	..
Width	..	4 ft.	4 ft.	..	..	..	3 ft.	..	..	..	..
Speed ..	..	30 ft.	77 ft.	..	..	..	80 ft.	..	..	..	..
Total employed—Men ..	12	10	4	5	32	16	8	12	4	15	5
Boys ..	15	14	23	13	11	48	30	15	25	21	13
Rate of Wages—Men ..	s. d. 3 11½	s. d. s. d. 3 2 to 3 8¼	s. d. s. d. 3 3 to 3 8¾	s. d. 3 5¼	s. d. s. d. 3 2 to 3 11	s. d. 3 10	s. d. s. d. 2 9½ to 3 7½	s. d. 3 2	s. d. s. d. 2 10¾ to 3 6¾	s. d. 3 6¾	s. d. s. d. 3 3 to 3 6½
Boys ..	1 9	1 2 to 2 6½	1 3¾	1 10½	1 1½ to 1 8	1 3 to 1 11½	1 1½ to 1 4¾	1 0¾ to 2 1½	1 0¾ to 2 1¼	1 0¾ to 1 10½	1 3¾
Cost per ton on gross ..	·97	·87	·62	·74	1·59	2·07	1·20	·95	1·39	1·88	1·33
" coal cleaned ..	1·31	1·19	·71	1·09	1·59	2·07	1·54	1·20	2·34	2·63	1·53
Class of coal ..	Steam	Steam	Steam and House	Steam	Gas	Gas	House	Steam.	Steam	Steam	House and Gas
	Cost includes 1,000 tons nuts per pay, unpicked.	Cost includes 800 tons nuts per pay, picked.		Cost includes 1,000 tons nuts per pay, unpicked.							

The actual cost has in each case been reckoned only on such labour as is employed for screening, cleaning, and loading, and is taken on the wages ruling in October, 1889.

BANKING OUT.

Amongst other advantages which the introduction of this system of mechanical screening offers, mention has already been made of the economy effected by the concentration of and consequently lessened amount of labour necessary for banking out.

Where the long range of fixed screens gives place to one or two of the newer type, it will readily be seen that the lessened distances the tubs have to travel opens the way to an appreciable reduction in the number of hands employed as banksmen.

Where it is possible a system of banking out by gravitation is, of course, the best that can be devised, and reduces the class and quantity of manual labour employed to a minimum.

The simplest arrangement for this purpose is that in which the tubs are conducted round a more or less circular course. The full tubs gravitate from the cage to the tip, preferably of a side-teaming type, and arranged so that the tub passes out at the opposite end to that at which it enters. The body rests upon rollers, to one of which motion is given when required by means of friction clutches (Fig. 23, Plate IX.) or wheels, or the motion (Fig. 24, Plate X.) may be regulated by means of a hand brake and stop. About three tubs per minute can be teamed by this means without any further labour being employed than that necessary for stopping and starting the tippler, and the arrangement can also be duplicated so as to empty two tubs at one operation on the same or separate screens.

The objectionable fall and breakage of coal which usually occurs with the employment of kick-ups is reduced considerably when the tub is turned sideways and a clean team is always ensured.

In situations, however, where an end team is indispensable an automatic sliding cover, such as that shown in Fig. 25, Plate IX., is a useful adjunct.

The empty tubs, after leaving the kick-up, are raised by mechanical means to a level sufficient to allow them to gravitate into the cage. For gaining the necessary elevation in such cases the design known as a "creeper" or "finger chain," which is described below, is perhaps the simplest and most satisfactory, as well as the cheapest, device that has hitherto been introduced.

Fig. 26, Plate VI., represents an arrangement on this principle now in course of erection at Harton Colliery, where the banking out is performed on two flats, the lower level being shown in full lines whilst the upper level is indicated in dotted lines. The coals from the high flat are tipped into a hopper, and screened at the same level as those from the low one.

The amount of power required can almost always be obtained from the screen engine, and the methods of attachment and detachment of the tubs being perfectly automatic, no attention or labour is required.

The form of creeper most generally in use consists of an ordinary link chain of the double and single link type, having links with projections, of sufficient height to catch the tub axles, placed at intervals varying with the speed and amount of work to be done.

On a level road, or for slight loads, it may be driven from either end, and at a speed of not more than about 80 feet per minute; but for heavy angles or loads it is better to drive from the leading end, and to use jaws on the driving tumbler.

For haulages over comparatively short distances, such as sometimes occur between the shaft and screens, a creeper will be found to be both economical and advantageous.

At Cowpen Mill Pit, where the heapstead is about 70 yards from the cages, the haulage is performed by a creeper 200 feet long, rising at a gradient of 1 in 7 to a total height of 24 feet. (Fig. 27, Plate V.) The chains are driven by an independent

engine (10 inch by 20 inch cylinder) placed at the top, and are carried in cast iron troughs or channels, that containing the full chain being fitted with rollers. The returning portions of the chains are carried in angle iron slides suspended in hangers from the gangway. (A, Fig. 27, Plate V.)

The engine is geared 16 to 1. The speed of the chains being 47 feet per minute, and the distances between the fingers 12 feet, the number of tubs (19 cwt. gross weight per tub) which can be raised per hour is 240.

The PRESIDENT said it would be well to let the members know at the outset that the discussion on the paper would be adjourned, but still he would be glad if some gentleman was in a position to commence the discussion to-day. There was an immense amount of most valuable information in detail and in principle laid before them, and he would be very glad to hear the remarks of any gentleman on the subject, especially if any one had anything in the shape of questions on any points on which they desired information at the next meeting. It was a matter of great importance.

Mr. A. L. STEAVENSON said perhaps the subject was not one on which much could be said until they had the paper before them for further consideration, but there could be no doubt that it was a very useful paper to have for reference, and although in their district the first thing to do was to clean the coals and the next to press them into a disintegrator, it was a subject of very great interest; the system described by Mr. Forster and Mr. Ayton was a very excellent one, and he could only suggest that on some other day, when the weather was warmer, the Institute should visit the pits and see these appliances for themselves.

Mr. J. R. BRECKON asked what would be the cost per ton to treat a given quantity of coal by the means described.

Mr. G. B. FORSTER pointed out that the information was all given in the table accompanying the paper, a copy of which was hung upon the wall as a diagram.

Mr. BRECKON said he had listened with pleasure to the reading of the paper, and also gathered some idea of the operation of the system described from the sketches on the walls. There was no doubt this was a move, in the right direction, of vast importance. Having had something to do with the disposal of coal in the market, it had been his experience that when the coal was treated in a careful manner at the screens, and sent into the market in a good clean condition, its disposal was a comparatively easy task, and a price could be realised for it far beyond that realised for coal not treated with such care. The system of screening by belts was a valuable and important invention, both as regards means of cleaning, ease with which it could be erected, and its economy, and so he felt certain they were moving in the right direction with regard to the treatment of coal, especially when they had to consider how to get the utmost price for it. For every penny expended for cleaning coal he ventured to say at least threepence or more might be realised on the price per ton vended—speaking in general terms. A system had been introduced in Scotland, at the works of Messrs. Murray & Cunningham, Motherwell, which seemed to him to deserve attention. The plant had been erected by the firm of Simon & Luhrig. Mr. Simon was a gentleman whose name was connected with the coke ovens introduced in Durham, notably at Peases' West and Bearpark. Mr. Luhrig was a German engineer; his plant had been extensively erected in Silesia, where 50 or 100 could be examined; but that at Motherwell was near at hand, and those interested might, if they thought it worth while, pay a visit to see what was done there. He might mention that the firm of Simon & Luhrig had been in treaty with one firm in the County of Durham to deal with an output of 1,800 tons per day, at a cost of a farthing per ton, being the entire cost of treating the coal. The system is worked by gravitation very largely and by belts, and whereas in the

To illustrate Mess.rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

FIG. 2.

Scale 1/8" to 1 Foot.

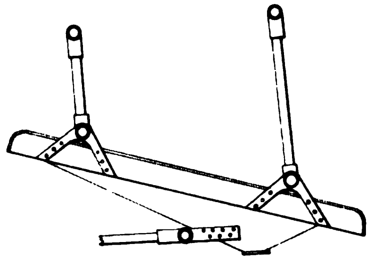


FIG. 9.

SHEWING ANGLE IRON ATTACHMENT.

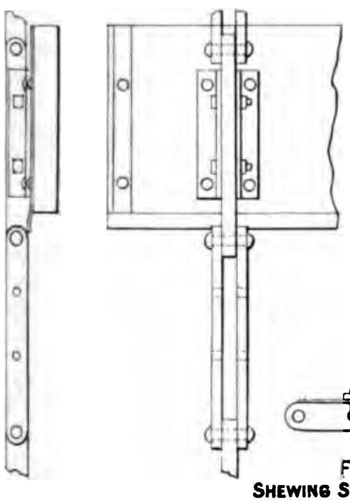


FIG. 7.

CAST STEEL JAW-LINK.

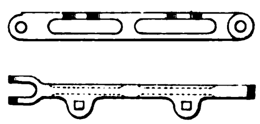


FIG. 8.

SINGLE AND DOUBLE LINK CHAIN.

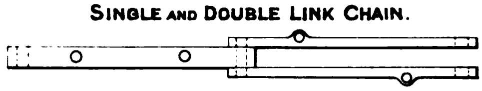


FIG. 10.

SHEWING HOOK-BOLT ATTACHMENT.

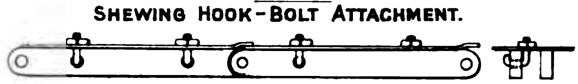
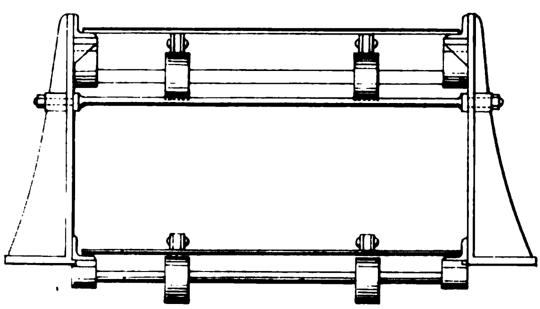


FIG. 9.

SHEWING STONE PARTITION

FIG. 11.

SHEWING ROLLERS AND SLIDES FOR CARRYING BELT.



Scale, 1" to 1 Foot.

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To illustrate Mess^rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

ARRANGEMENT FOR DISCONNECTING ENGINES.

FIG. 1.

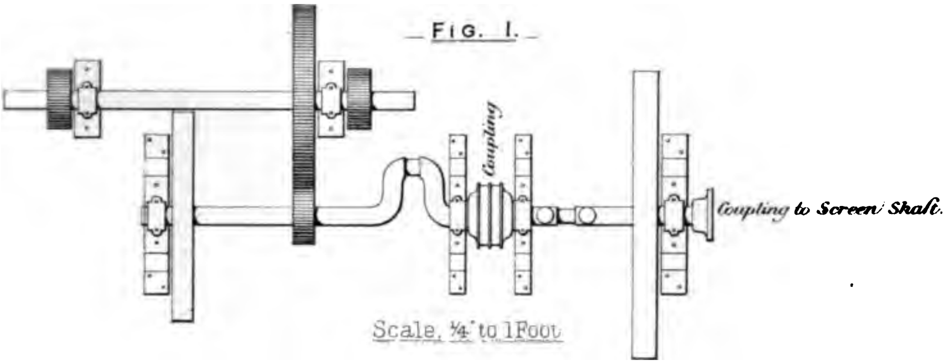


FIG. 3.

SQUARE MESH GAUZE

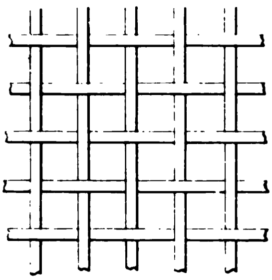


FIG. 4.

LOCKET WORK.

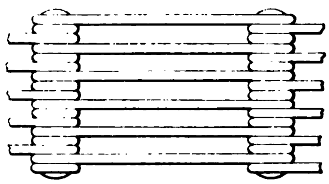


FIG. 5.

SECTIONAL LOCKET WORK.

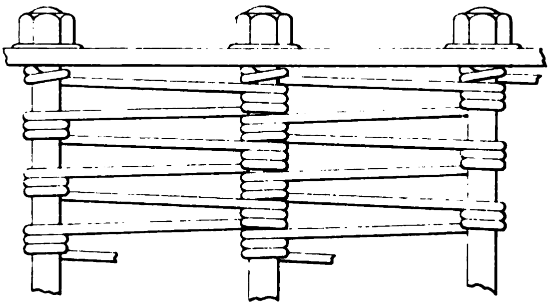
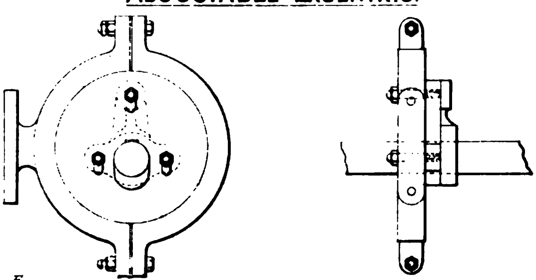


FIG. 16.

ADJUSTABLE EXCENTRIC.



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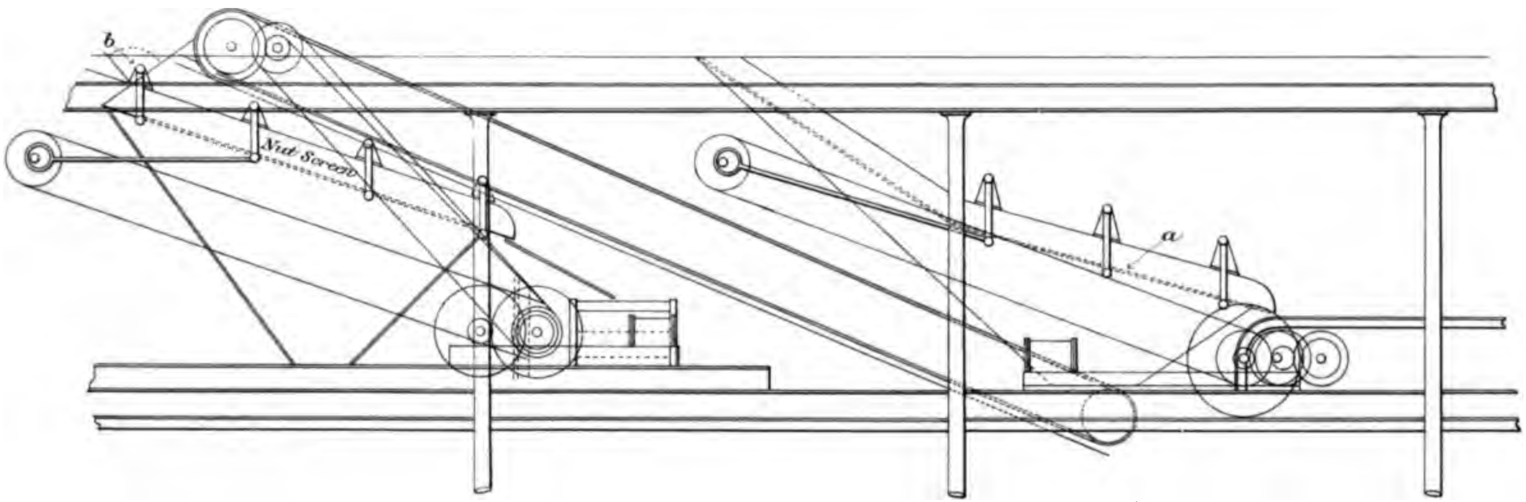
To illustrate Mess.rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

Arrangement of Screens and Elevating Belt at Ashington Colliery.

Fig. 6.



Scale ⅛ Inch to One Foot

Federated Institution of Mining Engineers
Proceedings 1889-90.

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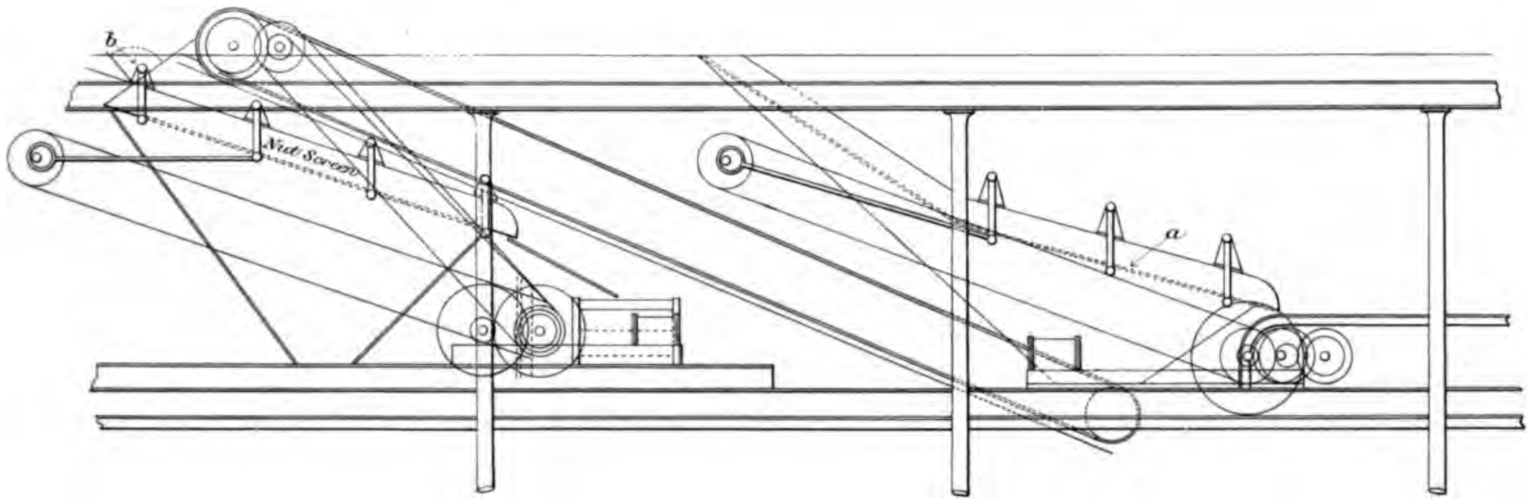
To illustrate Mess.rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

Arrangement of Screens and Elevating Belt at Ashington Colliery.

Fig. 6.



Scale ⅛ Inch to One Foot

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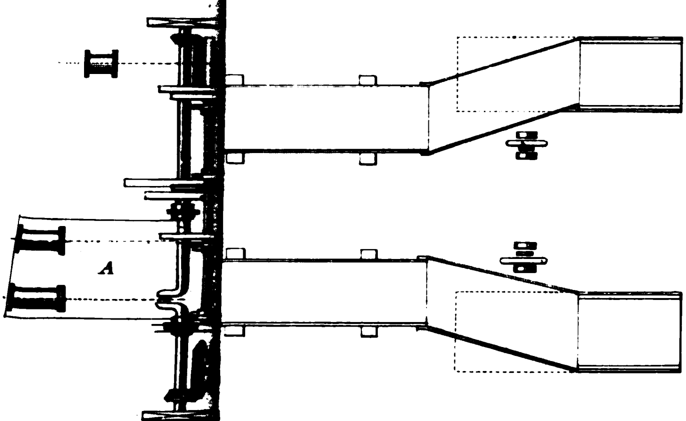
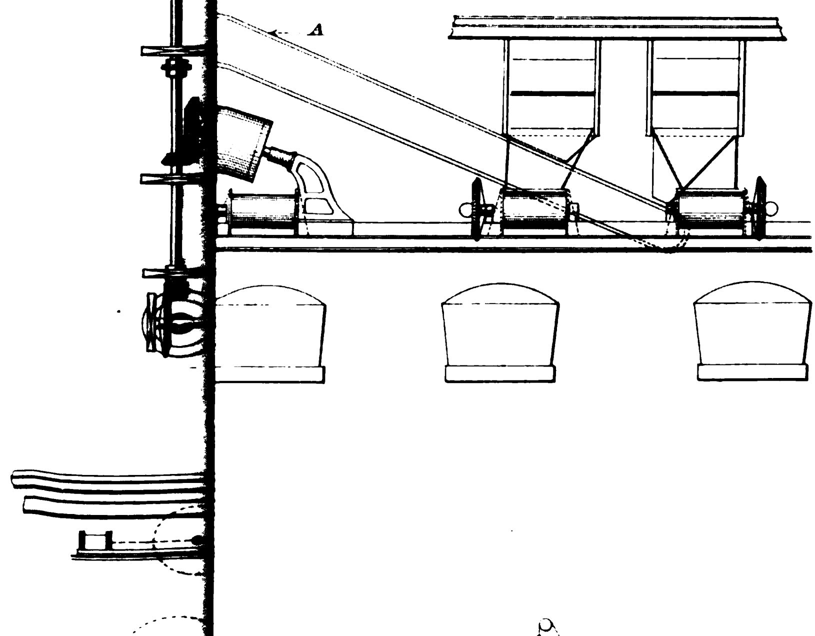
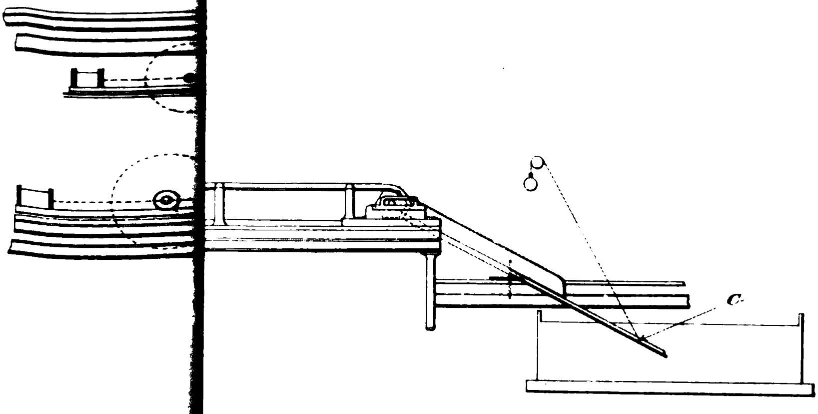


Fig. 14.
Elevating Belt and Nut Screens.





Weigh Table

Federated Instit...
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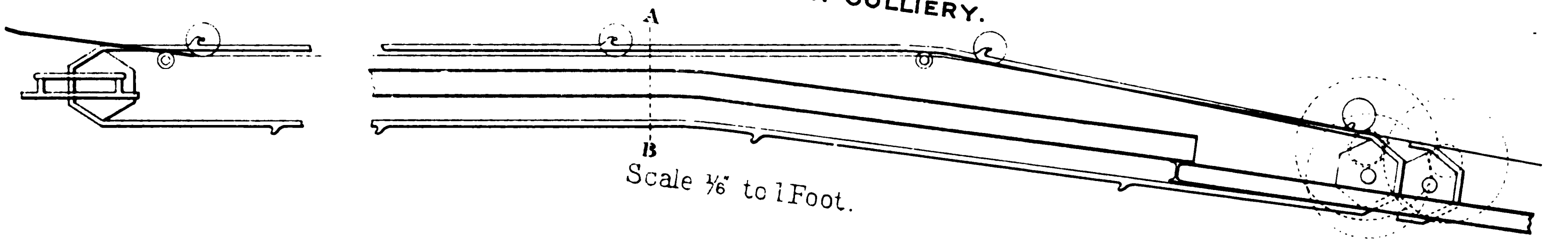
Vol. 1. Plate V.

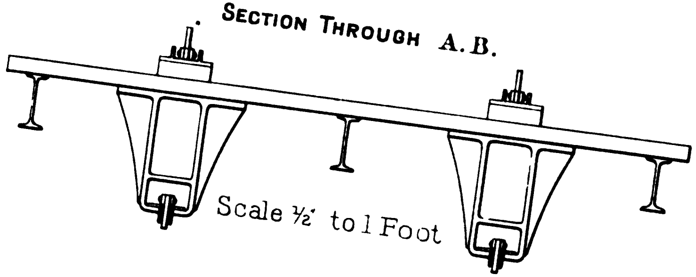
To illustrate Mess.rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

CREEPER
MILL PIT COWPEN COLLIERY.



Scale 1/6" to 1 Foot.

SECTION THROUGH A.B.



Scale 1/2" to 1 Foot

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To illustrate Messrs. Forster & Ayton's paper "on Mechanical Coal Cleaning."

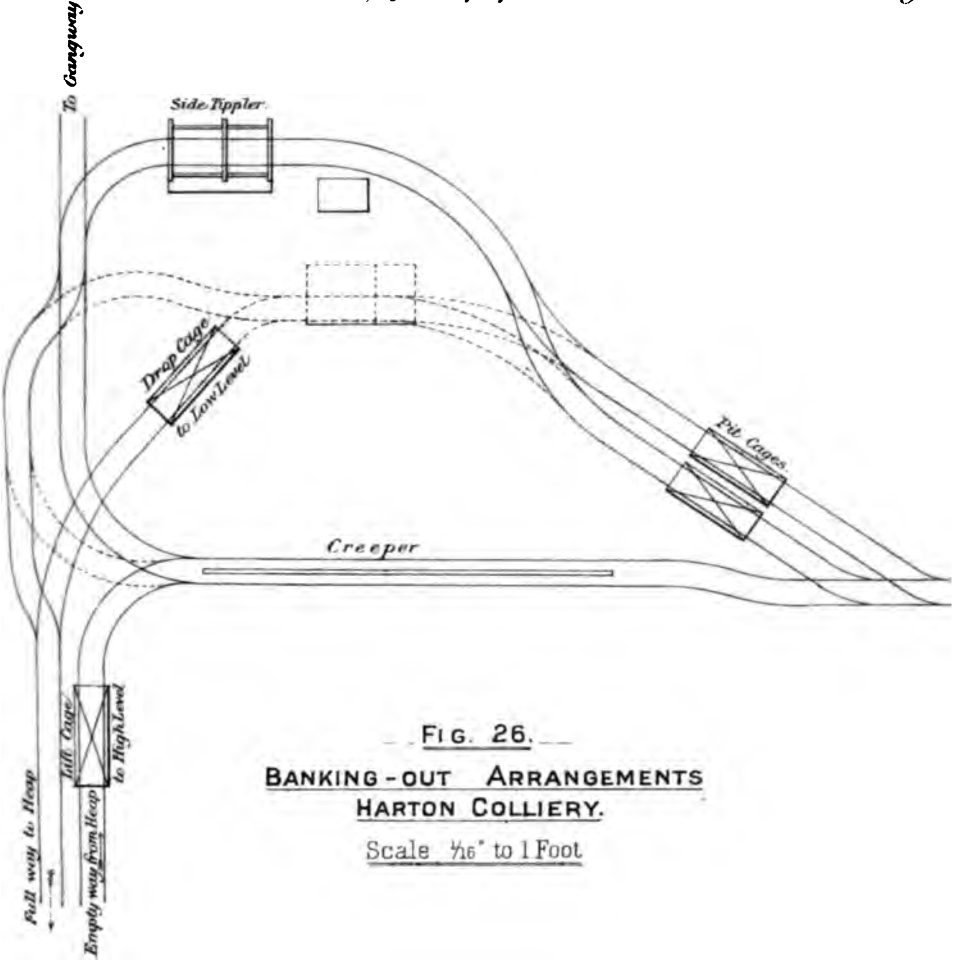

FIG. 26.

BANKING-OUT ARRANGEMENTS
HARTON COLLIERY.

Scale 1/16" to 1 Foot

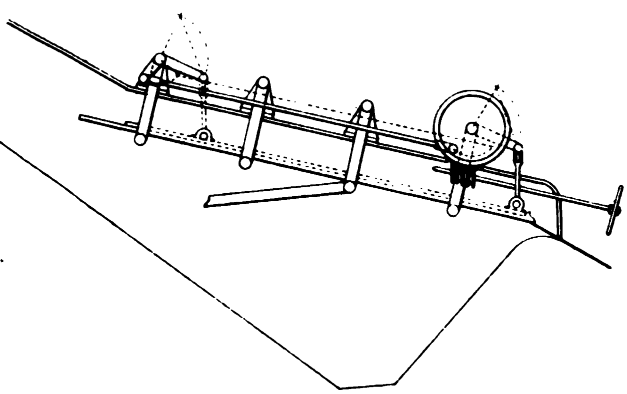

FIG. 12.

ARRANGEMENT FOR PLATING SCREEN.

Scale, 1/4" to 1 Foot.

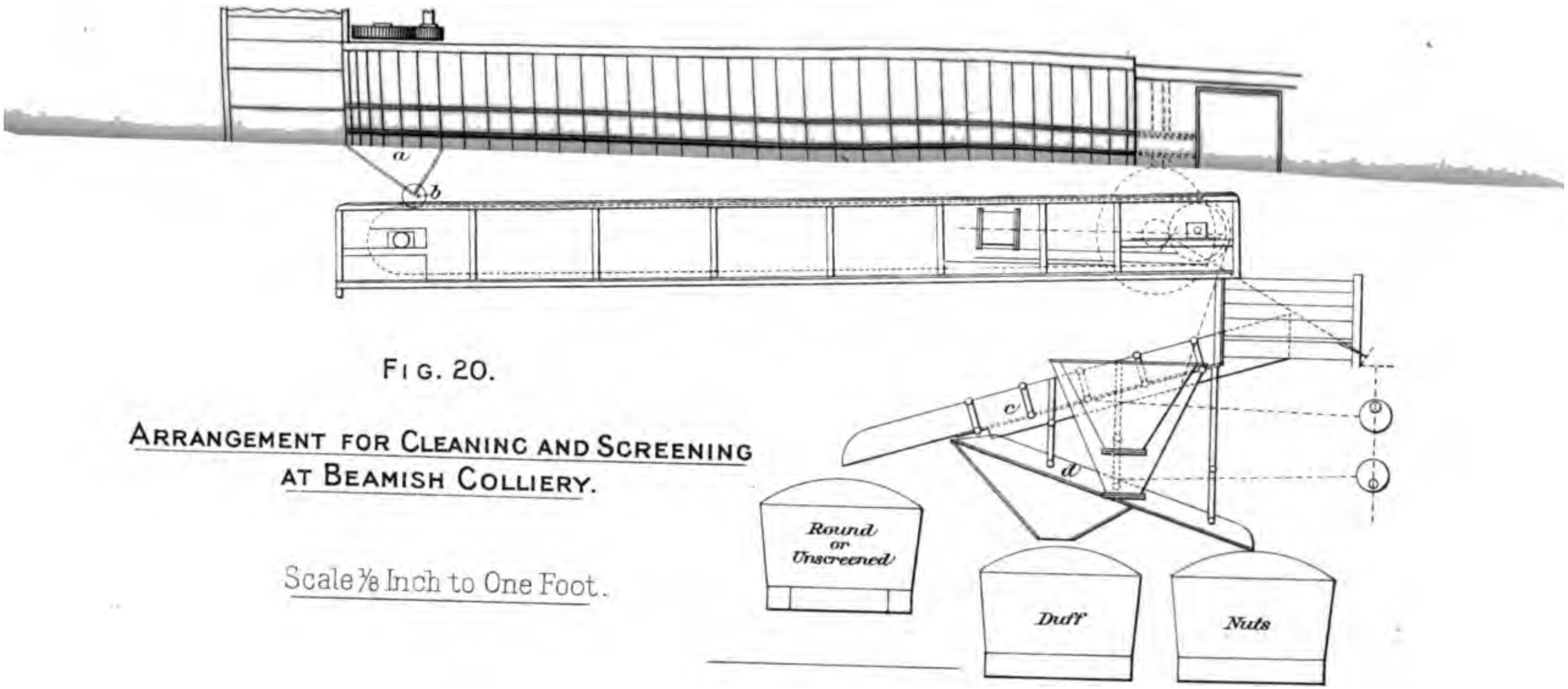

FIG. 20.

ARRANGEMENT FOR CLEANING AND SCREENING AT BEAMISH COLLIERY.

Scale ⅜ Inch to One Foot.

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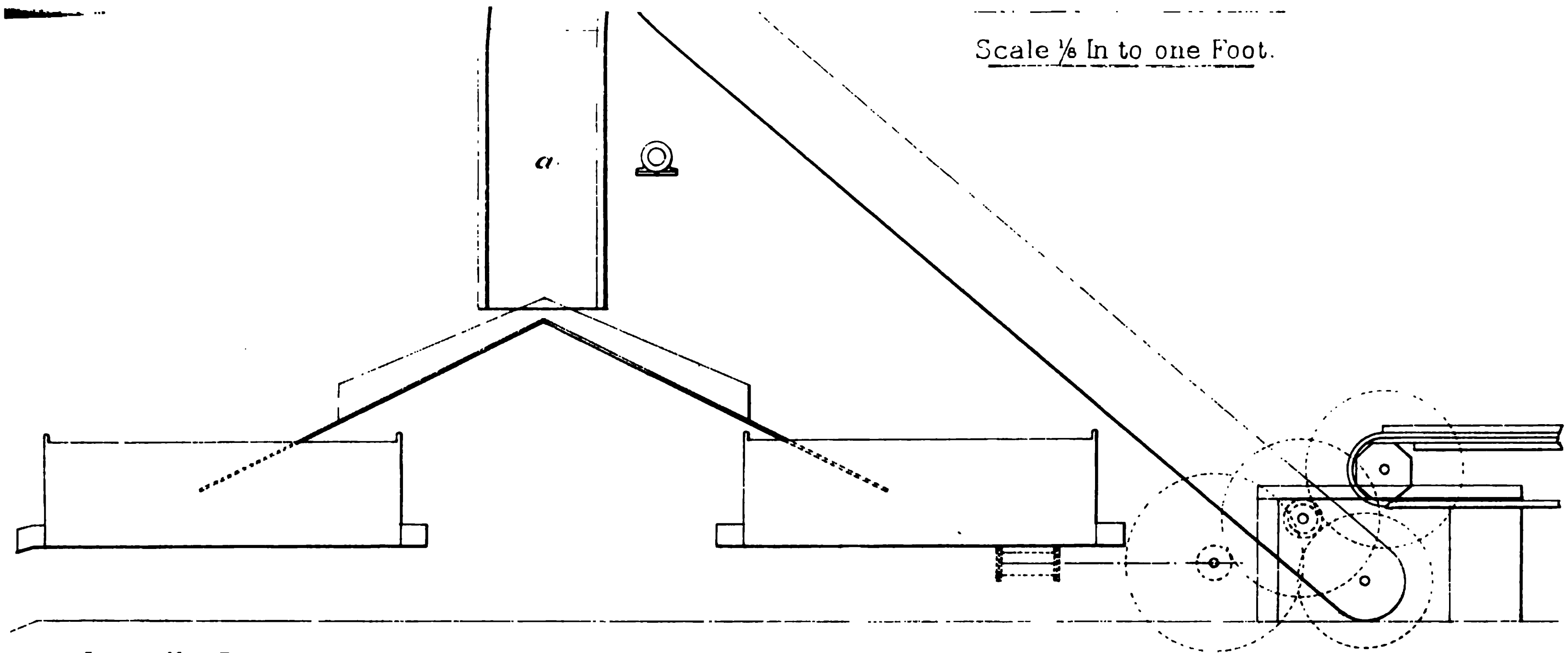
To illustrate Messrs. Forster & Ayton's paper "on Mechanical Coal Cleaning."

Scale ⅛ In to one Foot.



To illustrate Mess^rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

Fig. 23.

Design of New Revolving Kick-up
Harton Colliery.

Scale. 3/8" - 1 Foot.

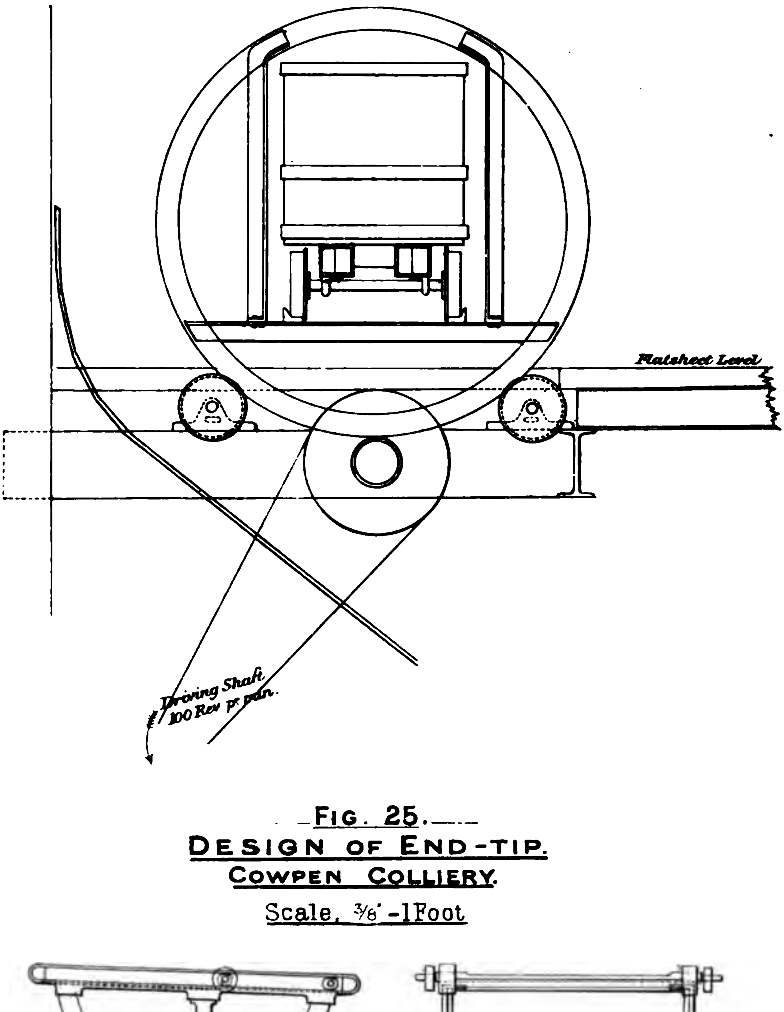


Fig. 25.

Design of End-tip.
Cowpen Colliery.

Scale. 3/8" - 1 Foot

And^w Reid Sons & C^o Lith... Newcastle

To illustrate Mess.rs Forster & Ayton's paper "on Mechanical Coal Cleaning."

PLAN SHOWING CONSTRUCTION AND POSITION OF A TIPPLER IN USE AT MARSDEN COLLIERY.

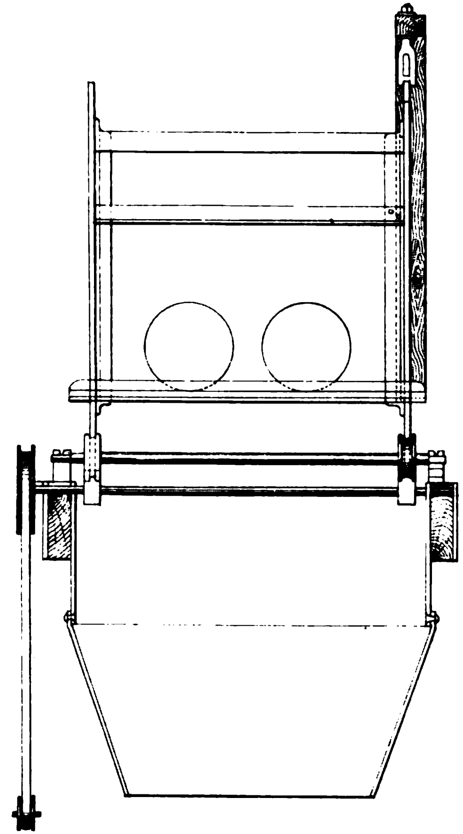
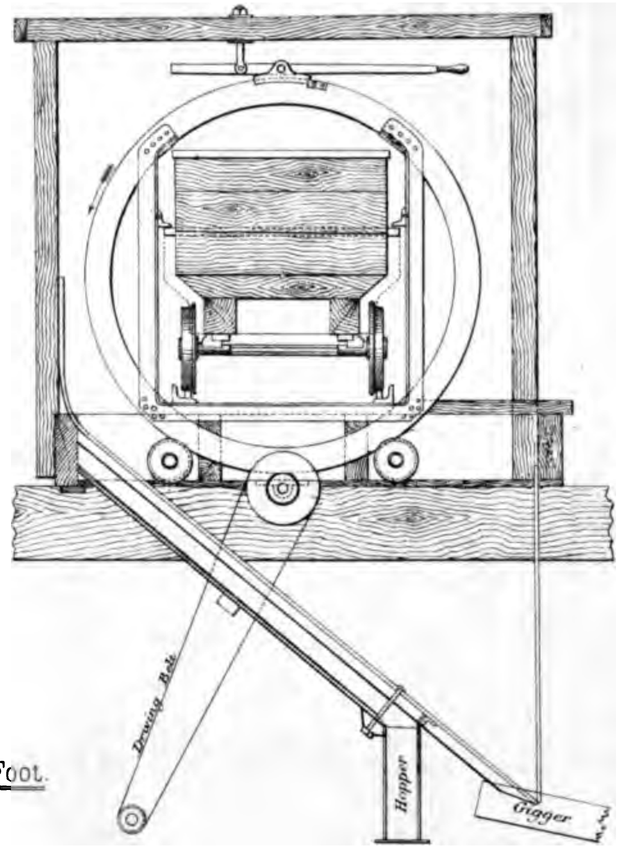


FIG. 24.



Scale, 3/8" to 1 Foot.

And.w Reid Sons & Co Lithos.

case of the colliery he referred to (with 1,800 tons per day), the cost was given by the colliery as £3,572 a year; with Simon & Luhrig's system, after allowing for the steam-power and machinery, it was only £562, which left a saving of £3,010. Another useful part of their appliance was this; speaking of coal picked out, they had an ingenious and simple contrivance by which they took the coal—which might have pyrites or shale attached to it—and by squeezers of sufficient force detached it from the pyrites and shale, and in that way at a very slight cost a considerable quantity of coal was obtained, for which a ready market could be found at a fair good price; and from other advantages in connection with this plant, he thought it might be said to be the most perfect contrivance yet known, and it seemed to him to recommend itself strongly to gentlemen considering this subject. He could not describe it from any drawing or from any accurate knowledge; he could only speak of its advantages in a commercial sense, and he thought it well to direct the attention of this meeting to the plant and the advantages it appeared to offer. It might be that in some respects the designs put before the meeting were better adapted to the requirements of collieries here, but in considering the subject he thought the plan adopted at Motherwell should be taken into account.

Mr. H. Ayton, referring to the diagram on the wall, explained that the cost of treating coal under the method described in the paper varied from ·62d. to 2d. on the gross quantity.

The President asked if there was any special leading charge into which the cost was divided. Of course, the tables on the wall could be examined in detail by any gentleman after the meeting; but what were the leading features?

Mr. Ayton read several of the particulars given on the table of costs.

The President—Then sufficient details are given, so that comparisons can be made with other systems.

Mr. Ayton—Yes. Rates of wages are also given.

Mr. Breckon—Does the cost given include steam power or use of machinery?

Mr. Ayton—No; just wages.

The President said it was important that questions should be asked to-day on any point which it was desired should be brought out.

Mr. M. Walton Brown thought the number of enginemen and men on the screens might be shown separately.

Mr. Ayton said as a rule only one engineman was employed, and sometimes he was only partly employed. He acts as screener.

Mr. Brown—That might be shown. There will be differences.

Mr. Ayton—The numbers of men and boys employed are generally in proportion to the length of the belt, and the lengths are given.

Mr. W. J. Bird asked if the authors of the paper knew of any particular arrangement of the system applied to accumulated and reserved stocks of screened coal, or unscreened and separated coal, which might be useful under circumstances with which they were all acquainted?

Mr. Ayton—The apparatus at Harton, which is not yet erected, has been adopted for that use.

Mr. Blackett asked if there was any means of turning the coal on the belt?

Mr. Ayton said that to turn over so that coal would not rest on the belt in large blocks a "spreading plate" was adopted (Fig. 13, Plate IV.) in the arrangement at Mill Pit. It had answered very well.

Mr. Blackett—But I am speaking of turning it over on the belt to look for stones.

Mr. Ayton—Nothing but hand-power.

Mr. T. H. M. Stratton said he presumed it would be too much to ask for the first cost.

Mr. AYTON said they had not gone into the question of first cost, it varied so much according to the conditions of individual collieries. They had gone into the matter of the maintenance of screens, but the time the screens had been running was hardly sufficient to give any fixed idea on the subject. So far as they had gone into the question they found that the bucket work compared very favourably with the old fixed screen bars, taking quantity for quantity.

Mr. DOUGLAS asked if there was any difficulty in driving the belt from the other end; if it could not be got at from the leading end, or in the case of a heavy inclination?

Mr. AYTON said he remarked in the paper that when this first came out the belts were often driven from the leading end; they are now, in the case of heavy loads. If the load was heavy, it had generally been found best to drive from the leading end; with a light load, and with a light inclination, it was matterless.

Mr. J. R. BRECKON asked if there was any experience to show whether the coal treated by this means, as compared with the old-fashioned screens, found more favour with the buyers? To put it even more strongly, whether any portion of the coal—nuts, small, peas, or screened coal—had been found to realise any higher prices? After all it came very much to the question, how will these operations tell upon the balance sheet? If there were any such particulars they would be interesting.

Mr. AYTON said he was sorry they had no data one way or the other on that point.

Mr. KENNETH GUTHRIE said he would be glad to have some information as to revolving tables. He believed they were used at many collieries, and were very well suited for laying out tubs to get at the dirt.

Mr. AYTON said, although they had touched on mechanical screening, they had not gone into the question of revolving tables. They had found it best to confine themselves to the methods in use in the North of England. Revolving tables were more used in the South and Midlands.

Mr. G. B. FORSTER said, with regard to one set of screens described, he would be glad to adopt Mr. A. L. Steavenson's suggestion, and, when the temperature was rather better, to see the members of the Institute at Cowpen Colliery, if they would care to examine the screens and anything else there. They would also have an opportunity of visiting the rising port of Blyth.

Mr. M. WALTON BROWN proposed a vote of thanks to the writers of the paper for the clear way in which they had put the matter before the members.

Mr. J. R. BRECKON seconded.

The PRESIDENT said he was sure they would all join in the vote of thanks. The subject of the cleaning and manipulation of coal after they had got them to bank was, he thought, of great and vital importance. Of course, Mr. Breckon must not expect them to get any chemical change in the condition of the coal which he thought he seemed rather to aim at, they only got mechanical change. If he succeeded in getting coal which he did not get before, the balance sheet would no doubt be very much improved. He would only remind them that this would be one of the papers published in the next part of the Proceedings of the Federated Institute, but at or before the end of March he expected they would have it in full print to discuss it, and he hoped the weather before that time would be sufficiently genial for their friend Mr. Steavenson and other members to accept Mr. Forster's invitation.

The vote of thanks was cordially adopted.

Dr. F. COLET LARKIN exhibited and explained "A new Mechanical Device for the rapid fixing of Surveying Instruments."

The proceedings then terminated.

INAUGURAL MEETING OF THE FEDERATED INSTITUTION OF MINING ENGINEERS,

HELD AT SHEFFIELD ON WEDNESDAY, JANUARY 22ND, 1890.

PRESIDENTIAL ADDRESS.

BY MR. JOHN MARLEY.

Gentlemen, brother members of the Institution of Mining Engineers, as it was considered you naturally would like to have a few words said to you before you commenced the more formal proceedings, I have, as your President, taken the opportunity of jotting down, very briefly indeed, a few remarks to make to you, and which I will now take the opportunity to read.

On this, the first General Meeting of the Federated Institution of Mining Engineers, it is fitting that our proceedings should be prefaced by a few words of welcome from myself as your first President and as your Chairman of to-day.

In congratulating you upon the fair start which this meeting implies I would wish to recall very briefly the various steps to which this Institution owes its being.

For many years past most of my predecessors in the office of President of the North of England Institute of Mining and Mechanical Engineers have advocated the desirability of some form of common action between the mining institutes of the country. Sir George Elliot, in 1868, and later on Mr. George Baker Forster, followed still more decidedly by Mr. John Daglish, all urged the advantages of federation. It was not, however, till the late Mr. T. W. Bunning's paper was read at Newcastle, in 1887, that a practical basis of operation was placed before the mining public. This paper, which we must look upon as the first document connected with our corporate existence, led, after the issue of a circular in December of the same year, to an important meeting being held in the Council Chamber of the Institute of Civil Engineers in London, on the 6th June, 1888. At this meeting the chair was occupied by Sir Lowthian Bell, Bart., and representatives were present from the North of England Institute, the Chesterfield Institute, the Midland Institute, the South Staffordshire and the North Staffordshire Institute.

The whole scheme of Federation was then very fully discussed and a committee was appointed to further the conclusions arrived at.

Several meetings of this committee followed, at Sheffield and in London, until at last in April, 1889, in London, a set of rules were agreed upon and recommended. These recommendations having been accepted by *four* of the above-named Institutes, a Council was formed according to the new rules. This Council met for the first time on the 11th of September at Newcastle-on-Tyne, when it was finally constituted by the addition of the prescribed number of co-optated members, and at the same time the Publication Committee was appointed. This latter body met shortly after in Sheffield to settle its mode of procedure, and their views having been adopted by the Council at its second meeting at York last November, the actual work of publication was at once commenced. That they have carried out this work with vigour is shown by the fact that notwithstanding the short time at their disposal the first parts both of the Proceedings and of the Transactions are already before us.

Besides publication, however, it must not be forgotten the Federation has other objects, namely:—Experimental research and occasional communication on contemplated actions which interest mining.

These are objects, however, which will require time and opportunity for development, and which it would be unwise to hurry on the accomplishment of unnecessarily.

The Council selected the Midland district for the first general meeting of the Institution, and the manner in which the Midland Institute, who kindly undertook the task of making the necessary arrangements, have carried out the wishes of the Council this day at once shows the abundance of their resources and their zeal for the welfare of the Federated Institution.

You have before you this afternoon three papers—one on Local Geology, another on Coal-getting by Machinery, and a third on the Application of Electricity to Mining. The last two are subjects which, as it seems at present, have a great future before them. The machinery referred to and the other development of mining science in the district you now have an opportunity of carefully examining for yourselves.

After dinner this evening it will be your privilege to be hospitably welcomed to this town of Sheffield by the Mayor and Master Cutler at a reception and conversazione, with which it is their pleasure to recognise in the most handsome manner the status of this young, but I trust I may add, important and vigorous Association.

In England all great corporations are the result of gradual growth, and we must expect this to be the case as regards ourselves. That the beginning we are making is promising will be clear to all when I state that whereas the *eight* Institutes mentioned in the late Mr. Bunning's paper, numbered altogether 2,584 members, the four which have united in the present movement comprise over 1,200 members.

Before formally pronouncing this meeting open I beg to announce that the Council have fixed the 30th of April next as the date of the next general meeting, which will be held in London.

The following paper on "The Geology of the Southern Portion of the Yorkshire Coal-field," by Mr. R. Russell, C.E., F.G.S., was then read:—

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

THE GEOLOGY OF THE SOUTHERN PORTION OF THE YORKSHIRE COAL-FIELD.

By R. Russell, C.E., F.G.S.

The Council of the Midland Institute of Mining, Civil, and Mechanical Engineers having asked me, through their Secretary, Mr. T. W. H. Mitchell, to give a sketch of the geology of the district in the place of Professor Green, who was unable to be present here to-day, I agreed to do so as far as the time at my disposal and other circumstances would permit. I selected "The Geology of the Southern Portion of the Yorkshire Coal-Field" for a subject; but I afterwards regretted that I had not confined myself to some particular group of the Coal-measures in this district rather than extending my remarks over such a wide area as is included in South Yorkshire. As the time and space at my command are limited, I shall, therefore, only give a summary of the coal-bearing strata in the neighbourhood of Sheffield and Barnsley, and occasionally a fuller description of the nature and character of some of the more important beds. The area which I propose to traverse extends from the southern boundary of the county to the district where the great change takes place in the character of both the Silkstone and Barnsley coals. Roughly speaking, this district extends from Kirkburton, through Cawthorne and Mapplewell, and thence north-eastwards through Havercroft, to the district south of Pontefract, and may be said to divide the coal-field into a northern and a southern section. I shall leave the correlation of the strata in the southern section, with the measures in the northern section, until some future occasion, when I may have an opportunity of bringing this part of the subject before the members of this Institution.

Two sets of faults traverse the country included within the limits above-named: one of which trends north-west and south-east, and the other north-east and south-west. They are, in fact, approximately at right angles to each other. The throw of these faults ranges from a few feet or yards up to 200 yards. 20, 40, and 60 yards' faults are of frequent occurrence.

The general strike of the beds is north-west and south-east, and the dip is to the north-east at a small angle of inclination, varying from half an inch to three inches in the yard. There is one exception to this general rule, and that is in the narrow strip of country between the fault on the south side and the fault on the north side of the River Don. Within this space the strike of the strata is north-easterly, and the dip to the south-east to an angle of from 25 to 50 degs. Here, also, owing to the high inclination of the measures between the southerly and northerly Don faults, the outcrops of all the rocks from the horizon of the Whinmoor Coal up to the Dalton Rock occur.

General Table of the Strata in the Southern Portion of the Yorkshire Coal-Field.

	Feet.
Upper Unconformable Coal-measures:—	
Red Rock of Rotherham ... ... }	240
Red Beds with Coal Plants ... ... }	

	Feet.
Middle Coal-measures:—	
Strata, with Wickersley and Brierley Rocks, irregular Sandstones, and thin Coals	1,100
Shafton or Nostel Coal—Strata, with Upper, Middle, and Lower Chevet Rocks, and thin bands of Coal ...	780
Treeton Rock, Oaks Rock, or equivalent strata ...	
Strata, with thin Coals	
Woolley Edge Rock	
Wathwood Coal—Strata, containing five workable seams of Coal	540
Barnsley Coal—Strata, with thin Coals	210
Swallow Wood Coal—Strata, containing Tankersley Ironstone, Flockton Coals, Fenton's Coal, Black Mine Ironstone, and Park Gate Rock	540
Park Gate Coal—Strata, containing three workable seams of Coal, Silkstone Rock, and Claywood Ironstone	300
Lower Coal-measures:—	
Silkstone Coal—Strata	210
Whinmoor Coal—Strata, with Penistone Flags, Penistone Coals, and Grenoside Sandstone and Coal	630
Brincliffe Edge Rock or Elland Flagstone	540
Strata, with irregular Sandstones and thin Coals ...	
Ganister or Hard Bed Coal—Strata, with Middle Bed Coal and Middle Bed Rock (Ganister Group)	150
Coking or Soft Bed Coal—Strata, with Crawshaw Sandstone and Soft Bed Flags	120
Thin Coal and Underclay	—
Millstone Grit	—

Thin Coal and Underclay.—The top of the coarse grit, known as the Rough Rock, is taken as the natural lithological division between the Millstone Grit and Lower Coal-measures of the Carboniferous series in Yorkshire. This horizon, in the southern portion of the Yorkshire coal-field, is marked by the presence of thin bands of coal and underclay, which are most constant in their occurrence throughout the district. The coal is worthless, but the underclay is valuable as a fireclay, and has been extensively worked nearly as far as Huddersfield; but about here the quality becomes inferior, and while the underclay continues to be represented, it is not considered of much importance or value.

South-west of Sheffield the Lower Coal-measures are thrown down against the Millstone Grit by the faults from Parkhead northwards to Fulwood Chapel, and from Fulwood Chapel north-east through Stephen Hill to the Sheffield fault north of Upper Walkly; and there are, therefore, no exposures of the thin coal and underclay between the county boundary and the Rivelin Valley. They, however, crop out in the valley at the junction of Storr's Brook with the River Loxley. The workings here gave the following sections:—

	Ft. In.		Ft. In.
Black Shale, with fossils	—		—
Coal	0 0½		—
Ganister	0 3	to	0 4
Fireclay	2 6	„	5 0
Gritstone (Rough Rock)	—		—

They again appear near Westfield, on the upcast side of the fault which trends from the Rivelin Paper Mill to Woodhouse Farm, in the Loxley Valley, and running round Ughill Moors are also exposed in Reyds Clough, which cuts down to the upper beds of the Millstone Grit. Here the thickness and quality is similar to that in Storr's Brook; and in the valley of Load Brook the grey clay, or upper part, 2 feet thick, is described as good for crucibles, and the hard grey clay, or lower part, 2 feet 6 inches thick, is mentioned as suitable for bricks.

In the valley of the Little Don, near Midhopestones, the section is as follows:—

	Ft.	In.
Dark Grey Shale, with fossils	—	
Black Shale	0	5
Coal	0	4
Underclay (Fireclay)	4	0
Sandstone (Rough Rock)	—	

And in the railway cutting one mile south of Honley the section given below was exposed:—

	Ft.	In.
Shale	—	
Coal	0	2
Ganister	0	4
Underclay	2	0
Sandstone and Shale (Rough Rock)...	6	0

The fireclay seems to be somewhat sandy, and when followed some distance inwards from the outcrop becomes harder and more like sandstone or ganister. It is used for the making of fire-bricks, is very refractory, and suitable for all purposes that require a fireclay capable of standing exposure to great heat. It contains about 25 per cent. of silica, and 75 per cent. of alumina, and only traces of iron oxide and calcium.

The strata above the fireclay contains a sandstone which has been distinguished by the name of the Crawshaw Sandstone, as it is very largely developed at Crawshaw Wood, on Ughill Moors. Here it is about 150 feet in thickness, and the total distance between the coking coal and the fireclay cannot be much less than 220 feet. The position of this sandstone on the south-west side of Loxley Valley appears to be almost wholly occupied by shales; but on the north side of this valley it is again present. It is also strongly represented on Onesmoor and Onesacre, where it occupies a large area, running down on the west side of the Don valley as far as Middlewood, where it is cut off by a fault north of Wadsley Park. At Middlewood the Crawshaw Rock is a thickly-bedded and coarsely-grained sandstone; but over Onesmoor and Onesacre it is thinly bedded, finely grained, and flaggy. On the east side of the River Don, at Oughtibridge, the coking coal rests on a flaggy sandstone, but at Black Roches, near Stocksbridge, there are strata consisting of dark sandy shales with thin bands of sandstone, about 30 feet thick, between this coal and the equivalent of the Crawshaw Rock. About Langsett the sandstone is absent altogether, and the distance between the fireclay and coking coal is only about 100 feet. The beds continue to possess the same character as far as Honley. North of Honley a bed of sandstone comes in once more below the coking coal, and this rock, in the neighbourhood of Huddersfield, is termed the Soft Bed Flags. At Mold Green, near Huddersfield, this sandstone has been proved to be 111 feet thick, and the total thickness of the group to be 150 feet 4 inches.

The details are as follows:—

	Ft.	In.
Soft Bed or Coking Coal	—	
Seat Earth	—	
Soft Bed Flags...	111	0
Black Shale	33	0
Fireclay...	6	0
Coal	0	4
Sandstone, Rough Rock	—	

The Soft Bed Flags consist of sandy micaceous sandstone, thinly bedded, and in some instances very false bedded. They are extensively quarried and yield good flags.

Coking or Soft Bed Coal.—The Coking Coal may be said to be one of the most regular and most continuous coal seams in the entire coal-field. It varies in thickness to some extent, but it is always present in some form or other, from the southern boundary of the county to the extreme northern limits of the coal-field. In the quarry at Ranmoor Cliff there is a coal and black shale band, 2 feet thick, lying immediately under the sandstone, which has been named the "Middle Rock." North of Ughill a coal 15 to 16 inches thick, and resting directly on the Crawshaw sandstone, has been worked formerly. There is a small outlier of a coal, 10 inches in thickness, occupying the same position at Greaves Bush, south-east of Onesmoor. South of the Railway Station a coal about 1 foot thick, lying on a similar horizon, is exposed in the railway cutting. West of Deep Car the coal has been very largely wrought throughout the whole district to the north-west. It is a thin band, ranging from 9 inches to 2 feet 10 inches thick. Generally, when the coal band is thickest, the greater thickness is partly accounted for by the presence of several layers of shale or dirt. North-west of Langsett the coking coal has been worked beneath Gilbert Hill and Brown Edge; at Ranah Cote, near Hazelhead Bridge, it was 1 foot 3 inches; north of Carlcotes, only 3 inches; south of Hepworth, 10 inches; at Barnside, 1 foot; and north of Hepworth, 1 foot 6 inches in thickness, and excellent in quality. North of New Mill it is 2 feet thick, but as we follow it northward, it again diminishes in thickness, being only 1 foot 2 inches to 1 foot 4 inches along the bank on the east side of the Holme Valley. About Huddersfield it again increases to 1 foot 6 inches. The quality of the coal is better at Far Town than farther south of Huddersfield, while north-east of Far Town it is so very inferior that it is almost of no value whatever.

Throughout the area which has been traversed this coal has been much used as a coke for smithy purposes, and was highly esteemed about Sheffield. The coal was burned in the open air and so converted into cinder. After the volatile matter had been driven off to a sufficient extent the burning coals were completely covered over with small refuse cinder and extinguished. Notwithstanding the smallness of the seam, the coal was much sought after, and furnished supplies of coke to most of the large forges in the vicinity of Sheffield in abundant quantity, although the average thickness of the bed did not amount to more than 1 foot 9 inches.

Strata between the Coking Coal and the Ganister Coal.—The measures from the Coking Coal to the Ganister Coal constitute a stratigraphical zone of a most distinct character. They contain a thin band of coal, known as the Clay Coal. This coal is most regular and constant in its occurrence over the portion of the coal-field now under consideration. In the south this group is about 150 feet thick, and might be represented generally thus:—

	Feet.
Ganister Coal	—
Measures	60
Clay Bed Coal	—
Measures, with the Middle Rock	90
Coking Coal	—
	150

In the neighbourhood of Sheffield a thick sandstone lies below the Clay Bed Coal. This sandstone is known as the Middle Rock. In the district north of Sheffield, and nearly as far as Warrall, it occupies most of the space from the horizon of the Coking Coal to the Clay Bed Coal. From Oughtibridge northwards, on the eastern side of the Don Valley, the sandstone is not quite so thick, and a band of shale lies between the Coking Coal and the Middle Rock.

The section at Oughtibridge is as follows:—

	Ft.	In.
Ganister Coal	—	
Ganister and Clay	—	
Shales	60	0
Clay Bed Coal	0	6
Clay and Bastard Ganister	2	0
Shale	6	0
Sandstone, Middle Rock	30	0
Shale	52	0
Coking Coal	—	
	150	6

The Middle Rock is most persistent in its occurrence, and can be traced almost continuously all over the country, from Sheffield north-westwards to Huddersfield.

The Clay Bed Coal is a hard carbonaceous band, somewhere between a black shale and a cannel coal. In the Sheffield district it is named the "Rattlers." This seam is worked wholly on account of the fireclay and ganister which lie below it. They are about 2 feet in thickness altogether.

Another thin coal band, hard ganister and underclay, occurs about 30 feet above the Clay Bed Coal. They were exposed in the brick pits and quarries near Rawson Spring Farm and in the old workings between Crookes and Spring Vale. They occur regularly in the district around Sheffield, but have not been observed elsewhere.

Near Deep Car Mill the section of the Middle Rock is somewhat different from anything that has as yet come under our notice. It is as follows:—

	Feet.
Ganister Coal	—
Strata, Black Shale, and Ironstone	45
Coal, Shale, and Underclay	1
Hard Sandstone	14
Coal	1
Underclay	4
Hard Sandstone	—

The coals, 1 foot thick each, may be the representatives of the Clay Bed Coal and the thin coal band above it, or the equivalent of the Clay Bed Coal alone.

In the district above Midhopestones the section is again of the ordinary type, thus:—

	Ft.	In.
Ganister Coal	—	
Shales	90	0
Clay Bed Coal	1	0
Light Clay	1	3
Bastard Ganister	4	0
Shales, with Sandstone at the top	115	0
Coking Coal	—	
	211	3

North of New Mill this group runs as given below:—

	Ft.	In
Ganister Coal	—	
Shales	24	0
Clay Bed Coal	0	6
Sandstone, Middle Rock	8	0
Shales	34	0
Coking or Soft Bed Coal	—	
	66	6

At Mold Green, Huddersfield, the section is rather more detailed, and runs thus:—

	Ft.	In.
Ganister Coal	—	
Black Shale	30	0
Clay Bed Coal	0	6
Sandstone, Middle Rock	11	6
Black Shale	12	0
Hard Bands	21	0
Shale	4	6
Coking or Soft Bed Coal	—	
	79	6

From what has been stated it will readily be observed that the ganister group continues almost the same from Oughtibridge north-west to the vicinity of Hazelhead and Carlcotes, from thence this zone thins away towards New Mill and Honley. This decrease seems to continue to go on regularly, for in the extreme north of the coal-field the distance between the Halifax hard and soft coals, the representatives of the coking and ganister coals of the southern district, is only about 30 feet.

Ganister Coal.—The ganister is a marked coal when it first enters Yorkshire, and is easily distinguished from one end of the district to the other. Formerly this coal was worked opposite Ecclesall Church; here the seam was 2 feet 3 inches thick, but there was no ganister below it. The ganister, however, soon puts in an appearance, and the workings at Greystone Cliff supplied the following section:—

	Ft.	In.
Black Shale	—	
Ganister Coal	2	6
Ganister	2	0

This coal has been most extensively worked, from the county boundary north-westwards along the south-west side of the coal-field. In the valley leading from Crookes to Spring Vale the ganister is not of the best quality, while the thickness ranges from 8 inches to 2 feet 2 inches. In an open quarry near Wadsley the coal and ganister were represented thus:—

	Ft.	In.
Ganister Coal	1	10
Ganister	2	9

South-south-east of Deep Car Station the ganister coal is 2 feet 4 inches in thickness. From Deep Car this coal ranges along the northern side of the Little Don valley.

At Stocksbridge both the thicknesses of the coal and of the ganister are variable; thus, the coal ranges from 1 foot 10 inches to 2 feet 8 inches, and the ganister from 10 inches to 3 feet.

About Midhopestones the coal is 3 feet thick, and the ganister only 1 foot; while at Bulhouse Colliery, near Hazelhead, the full section was as follows:—

	Feet.
Ganister Coal	3
Ganister	1
Underclay	3

Balls of iron pyrites coated with coal, and large carbonaceous nodules called "Bullions," full of fossils, occur here and there in the roof of the coal. The former have been used for the manufacture of H_2SO_4 (sulphuric acid), and the latter have been occasionally burnt for lime. Here the coal is used locally as a house coal.

Sections of a similar type prevail in the neighbourhood of Huddersfield, as, for example, the section of the coal worked at Field House Colliery:—

	Ft.	In.
Ganister Coal	2	4
Ganister	1	0
Underclay	3	0

The Ganister Coal is used mainly as an engine coal, but also locally for household purposes. It is only of a second-rate quality.

It is the excellent quality of the ganister which imparts the great importance to this seam. As a lining for the Bessemer converter and for the blast furnace the ganister obtained from the Ganister Beds of the southern portion of the Yorkshire coal-field is unrivalled for its high refractory qualities.

The group of strata from the Ganister Coal to the Brincliffe Edge Rock contains several important sandstones; but these, like the majority of the rocks of this class, are here and there replaced by shale, and not one of the members of this series is continuous throughout the whole extent of the coal-field.

The beds included in this group are:—

	Feet.
Brincliffe Edge Rock or Elland Flagstone	—
Shales	230
Wharncliffe Rock	70
Shales	50
Hard Bed Band Coal	—
Loxley Edge Rock	40
Shales	110
Ganister Coal	—
	500

Entering Yorkshire near Crabtree Bank, the Loxley Edge Rock extends northwards to Ellercliff, north of Deepcar. On the north side of the Rivelin Valley it occupies the high ground from Loxley along Loxley Edge to Spiteraite on the upcast side of the Sheffield fault. At Ecclesall it was proved to be 51 feet thick; but near Tapton it has been estimated to be 120 feet, and at Crookes Moor as much as 190 feet in thickness. Around Stannington the Loxley Edge Rock presents the character of an ordinary sandstone, but at Loxley it is a coarse massive rock, and very regularly jointed. On the east side of the Don valley it is readily distinguishable in Wharncliffe Wood; but while it can be followed up to and north of Deepcar, it forms no well-marked horizon calling for special mention.

The Wharncliffe Rock, on its first appearance within the county, is represented by a sandstone of some note. It appears to be less strongly represented for some distance north of Potter Brook; hence it does not appear in any of the sections about

Tapton and Crookes Moor. North of the River Don it again becomes conspicuous, and soon assumes a most striking form. In Old Park Wood it is a sandstone of a very ordinary character, and is about 50 feet thick; but on its reappearance in Wharncliffe Park its character is most distinctive. It is a very hard, massive, thick-bedded, close-grained, and highly siliceous rock, and where it makes the bold escarpment at Wharncliffe Crags it is probably 100 feet in thickness. On its first appearance north of the county boundary it may be said to be an insignificant rock, but in Wharncliffe Park it suddenly assumes a most conspicuous form, and at once becomes the most important bed of this group. It can be traced across the valley of the River Don at Soughley Bridge and Burnt Stones Plantation. Within a mile of these exposures it dies away as rapidly, and disappears altogether.

Brincliffe Edge Rock, Greenmoor Rock, or Elland Flagstone.—The Brincliffe Edge Rock, south of the River Sheaf, is much divided by shale bands. Crossing the Sheaf Valley, south-west of Heeley, these shale bands die away very soon after the rock enters Yorkshire, and along Brincliffe Edge the sandstone is strongly developed, and has been proved to be at least 105 feet thick. In the neighbourhood of Sheffield the thickness of this sandstone probably averages 100 feet. Northwards the sandstone again becomes much split up, and in the vicinity of Wadsley Bridge contains many shale bands. For some distance it continues to be very faintly represented, and about the middle of Wharncliffe Moor becomes so very feeble that it possibly disappears entirely over a small area. The sandstone, however, soon begins to recover strength, and gradually grows stronger and stronger, until three well-marked beds of sandstone come in south of Wortley Railway Station. These sandstones rapidly develop into a thick massive rock, which occupies a wide area, and forms the bold feature at Green Moor. In this district the Greenmoor Rock is the most important and excellent of all the Coal-measure sandstones. Here it is pale blue—finely, evenly close-grained, and thickly-bedded. It does not split into thin flags, in this respect differing in some degree from the Elland Flagstone; it is cut and sawn into blocks and flags.

At Brock Holes, north-west of Midhopestones, the sandstone is again divided by a shale band, and a similar shale band occurs in a deep bore-hole at Penistone. The section is as follows:—

	Ft.	In.
Hard Stone	16	6½
Blue Shale and Ironstone	14	8½
Hard Stone	11	10½
Gritstone	9	10
Hard Stone	1	5
	54	4½

There is apparently only one band of sandstone, about 50 feet thick, at Hartcliffe, where it forms a good escarpment. About Thurstonland the rock is in places very shaly. It has the same nature in the valley below Kirkburton and Highburton, is very variable in thickness, and does not average more than 40 feet in thickness. South-east of Huddersfield it consists of two variable beds of sandstone, separated by 30 feet of shale; and between Fenay Bridge and Huddersfield it is represented by three distinct beds of sandstone, the thickness of which is most irregular. As a general rule this sandstone is finely-grained, and made up of thin regular laminæ; it therefore splits readily up into flags of various degrees of thickness, and is used for roofing-slate, pavement, and building stone. Wherever the quality is good, which is usually the case, excellent flagstone is obtained from this rock.

Strata between the Brincliffe Edge Rock and the Silkstone Coal.—We now come to an irregular but important group, and this consists of the strata from the Brincliffe Edge or Greenmoor Rock to the Silkstone Coal:—

Silkstone Coal.
Shales with thin, irregular Coals
Whinmoor Coal.
Shales.
Penistone Flags.
Shales.
Grenoside Rock.
Tinker Coal = Low Moor Black Bed.
Shales.
Thin Coal = Low Moor Better Bed.
Brincliffe Edge Rock.

This series constitutes the upper portion of the Lower Coal-measures. It exhibits many very striking changes as the zone composed of these beds is followed from south to north. Leaving smaller variations out of consideration, the beds are easily classified into two typical divisions, which correspond to two distinct districts, one to the southern portion, and the other to the northern portion, of the coal-field. The district where the southern type changes into the northern type is situated somewhere in the vicinity of Huddersfield. We may further say, that the southern division is distinguished by massive but variable sandstones and by the inferior quality and small number of the thin coal seams which it contains.

In the extreme south of Yorkshire the very valuable Better Bed Coal of the north, if represented at all, is only present in a very doubtful and most meagre form. In Great Roe Wood, 65 chains north of Pitsmoor Church, there is a band of thin coal and black shale resting on a sandstone, the position of which corresponds to the horizon of the Greenmoor Rock. And near Brock Holes, north-west of Midhopestones, there is an underclay, bastard ganister, and coal smut occupying the same position relatively to the Greenmoor Rock that the Better Bed Coal does to the Elland Flagstone farther north. From hence northwards a fireclay can be followed very continuously along the same stratigraphical zone, thus, a bore-hole near the Blue Bell Inn, Thurlstone, gives the following section:—

	Ft.	In.
Grenoside Rock	—	
Shale	33	0
Fireclay	6	0
Shale	20	0
Greenmoor Rock	—	

In a bore-hole at Penistone the section is as follows:—

		Ft.	In.
Sandstone	Grenoside Rock	12	10½
Gritstone		62	4
Shale		34	10
Ironstone		0	8
Shale		21	0
Greenmoor Rock		—	

The ironstone at Penistone is exactly in the same position as the fireclay at Thurlstone.

A similar section is obtained from the bore-hole at Mill Bank Hall, Denby. Here a very hard fireclay lies about the same distance below the Grenoside Rock as the fireclay and ironstone given respectively in the two foregoing sections do, thus:—

	Ft.	In.
Grenoside Rock	64	6
Dark Shale	33	5
Very hard Fireclay	8	3
Very hard White Rock	2	1¾
White Shale, with Bands of Sandstone and Ironstone	60	4½
Elland Flagstone	—	

North-west of Farnley Tyas no indications of either coal or clay have been observed on this horizon, but farther north the thin band of coal above the Elland Flagstone improves in thickness and quality, and about Rowley and Highburton becomes of workable value. Hereabouts the coal is generally known by the name of the Better Bed Coal, a name by which it is distinguished throughout the whole of the northern district.

About Kirkburton the strata are represented as given below:—

	Ft.	In.
Grenoside Sandstone Coal	0	6
Grenoside Rock	40	0
Tinker Coal { Coal, 0 9; Dirt, 0 3; Coal, 0 9 }	1	9
Shale	50	0
Sandstone	20	0
Shale	30	0
Kirkburton Coal = Better Bed Coal	1	6
Elland Flagstone	—	

The Tinker Coal is unknown south of this district, and coincident with its appearance the Grenoside Rock begins to die away.

Grenoside Rock.—On the borders of Yorkshire and Derbyshire the Grenoside Rock is distinguishable, but seems to disappear east of the valley of the River Sheaf. North of Sheffield it assumes a very conspicuous form, and is one of the most notable of the sandstones belonging to the Lower Coal-measure series. It is largely developed at Grenoside, and occupies considerable areas along the east side of Wharncliffe Park, through Wortley, Hartcliff, and Thurlstone to Pickelow Hill, also around Thurstonland and Farnley Tyas, but is lost sight of in the country east of Huddersfield, and does not exist north of this place. Its lithological character is as constant as its geographical and stratigraphical extension, being invariably a thickly-bedded, rough, and gritty sandstone of a very massive type.

Penistone Flags.—These beds consist of several bands of flaggy sandstone, with intermediate beds of shale. The sandstones cannot always be traced with certainty, and they are apparently of a very variable nature. Sometimes they seem to consist wholly of sandstone, and sometimes of distinct sandstone bands separated from each other by beds of shale. Around Penistone, where they may be considered to be typically represented, there are two or three bands of flaggy sandstone, which are separated from each other by beds of shale. Generally, the sandstones are of a very shaly and fissile nature, but here and there throughout the district the quality of the rock improves and good flags are obtained from these beds. A thin bed of coal often overlies each band of sandstone, but while they possess some geological interest these occasional seams are not of any commercial value.

The following section shows the coals and sandstones of the Penistone Flags in the vicinity of Penistone:—

	Ft. In.	Ft. In.
Whinmoor Coal	—	
Strata, sometimes Sandstone ...		
Thin Coal	90 0	90 0
Shale		
Penistone Flags—		
Charlton Brook Coal	0 9	
Sandstone	30 0	
Shale	30 0	
Penistone Green Coal	0 9	
Sandstone	20 0	
Shale	25 0	
Lower Penistone Coal	0 6	
Sandstone	60 0	
		167 0
Shale	40 0	40 0
Thin Coal, Irregular and Bastard Ganister	—	
Shale	50 0	50 0
Grenoside Rock	—	
		347 0

Whinmoor Coal.—A coal seam has been worked in the neighbourhood of Sheffield, but very little is known about these old workings. However, the outcrop of a coal is seen at the south end of the tunnel on the Midland Railway, south of Sheffield Station; this coal is about 3 feet thick, and lies on the horizon of the Whinmoor Coal, some 70 yards below the Silkstone Coal.

Well, Brewery, Earl Street, Sheffield:—

	Ft. In.
Silkstone Coal	—
Strata, wanting	—
Strata	60 0
Coal and Dirt = Better Bed Coal	3 0
Strata	24 0
Coal Smut = Whinmoor	0 6

An outlier of the Whinmoor occurs on the hill top at Ecclesfield, and the coal is thrown down and crops out on the east side of the valley of the Blackburn, on the downcast side of the fault through Windmill Hill.

The section of the coal at the small colliery by Charlton Brook was as follows:—

	Ft. In.
Coal	0 2¼
Dirt	0 4
Coal ... ...2 ft. 2 in. to	2 4

In the workings about Pule Hill, north-east of Thurgoland, the total thickness of the seam was about 5 feet, of which 1 foot 7 inches to 2 feet 4 inches was workable coal.

At the Wharncliffe Silkstone Colliery the Whinmoor has quite recently been sunk to. Here it lies 65 yards below the Silkstone seam, and the following section of the coal has been furnished by Mr. G. Blake Walker:—

	Ft.	In.
Coal	0	6½
Band (pyritous)	0	0¾
Coal	1	3
Dirt	0	0½
Coal	0	11¼

In Deffer Wood, where the Whinmoor was formerly wrought, the section was:—

	Ft.	In.
Coal	2	0
Dirt	1	2
Coal	1	0

The outcrops of the Whinmoor and Black Band Coals are exposed in a sufficient number of instances, and these, taken together with the escarpment of the sandstone. which generally lies above the Whinmoor Coal, enable the outcrops to be laid down with some accuracy from Meadow Hall, in the valley of the River Don, north-west by Wortley and Emley to Shelley.

Measures about Shelley:—

	Ft.	In.	Ft.	In.
Blocking Coal	—			
Strata	70	0		
Thin Coal Band	1	0		
Strata	84	0		
Black Band Coal	1	6		
Strata	33	0		
			189	6
Whinmoor Coal—				
Coal	0	6		
Dirt	1	0		
Coal	1	2		
Dirt up to	4	0		
Coal	1	2		

Silkstone Coal.—The Black Shale Coal of Derbyshire is generally known in the neighbourhood of Sheffield and over the southern portion of the coal-field under the name of Silkstone Coal. This coal is very uniform in thickness and quality in the country lying between Sheffield and Cawthorne. It usually consists of two layers of coal with an intermediate parting of shale. The upper layers vary from 1 to 3 feet, and the lower layers from 1 foot 9 inches to 3 feet 7 inches thick; the shale or dirt parting runs from 1 inch up to 1 foot in thickness, unless in the district from Kimberworth to Chapeltown, where the shales between the two layers of coal increase locally to about 30 feet. Towards Cawthorne the parting in the Silkstone also thickens very considerably, and other changes in the nature of the coal take place. The layers of coal are still further split up by bands of shale, and the individual beds of coal diminish in thickness, indicating, as it were, their complete disappearance northwards. The serious deterioration of the Silkstone Seam in the vicinity of Cawthorne has rendered any endeavours to follow this coal futile, and for some distance north-west of the village hardly anything is known about its character. Coals have been worked around High Hoyland and West Clayton which undoubtedly occupy the same stratigraphical zone as the Silkstone Coal and the strata immediately overlying it, but these coals are of a very inferior quality.

About Emley and Flockton there is a series of coals occurring on a corresponding horizon, and these beds agree in some measure with the coals which in the country to the south lie between the Silkstone and the Parkgate Coals.

The following sections of the Silkstone Coal show some of the variations which take place in the character of the seam:—

Woodthorpe Colliery.

	Ft.	In.
Branch Coal	1	2
Coal	1	4
Dirt	0	7
Low Coal	3	7

Hoyland Silkstone Colliery.

	Ft.	In.
Hard Coal	2	1
Soft Coal	1	0
Dirt...	0	8
Bottom Coal	2	7
Seat Coal	1	2

Barrow Colliery.

	Ft.	In.
Branch Coal	0	9½
Top Softs	1	10
Dirt...	0	4½
Bottom Softs	2	0
Seat Coal	0	6

Stanhope Silkstone Colliery.

	Ft.	In.
Top Coal	2	3
Dirt...	1	0
Coal, with Iron Pyrites	0	11
Dirt...	2	6
Coal	1	3
Seat Coal	0	3

Day Hole, Dog Kennel Gate, Cawthorne.

	Ft.	In.		Ft.	In.
Coal	1	5	to	2	4
Dirt	—			1	8
Coal	0	10	to	1	0
Stone	—			2	0
Coal	—			2	0

Bore-Hole in the Thistley Close, Cinderhill, Cawthorne.

	Ft.	In.	Ft.	In.
Coal			1	10
Dirt...			2	0
Coal			0	9
Blue Sandy Shale... ...	17	0		
Blue Sandstone	0	6		
Blue Sandy Shale... ...	2	8		
Blue Sandstone	0	8		
Blue Sandy Shale and Shale	2	4		
			23	2
Coal			1	5
Dirt...			0	4
Coal			0	5

Falconer Colliery.

	Ft.	In.
Coal	1	6
Soft Dirt	0	1
Coal and Shale	0	5
Underclay	1	8
Coal	0	5
Sandstone	—	

The section of the coal at Falconer Colliery was not proved beyond the depth given above, but it agrees very nearly with the upper band of coal found in the bore-hole near Cinderhill.

As an indication of the beginning of the great change which takes place in the nature of the Silkstone Coal the sections last given are most interesting. They not only show that the thickness of the parting between the two layers of coal increases very largely, but that the bands of coal themselves become divided in such a manner as to be rendered almost worthless. The failure of the attempt to win the coal at Kexborough has put an end to any further explorations north of Cawthorne; and as it is not possible to follow these variations at the surface in the absence of good sections, but little is accurately known of the general character of the coals on this horizon in the district between Cawthorne and Emley.

Under its typical form the Silkstone Seam is a pure bituminous coal of the very best quality. It has long held a high place amongst coals for household purposes, a reputation which it thoroughly merits. It also makes an excellent coke. At Aldwarke Main Colliery the yield of coke is 64·74 per cent., and the analysis of the coal gives:—ash 1·88, and sulphur 0·78 per cent.

Claywood Ironstone and Silkstone Rock.—The Claywood Ironstone lies from 12 to 14 yards above the Silkstone Coal. It consists of layers and nodules of ironstone

lying in black shale. The ironstone layers range from 1 inch up to 4 inches thick; the total thickness of all the layers seldom exceeds 1 foot 8 inches, and is frequently less. This ironstone has been largely worked in the vicinity of Chapeltown.

The Silkstone Rock lies either directly on or a short distance above the ironstone-bearing shale. This sandstone is sometimes as much as 90 feet thick, sometimes it is much split up by shale bands, and sometimes it disappears altogether.

In the measures between the Silkstone Rock and the Park Gate Coal the workable seams of coal are the Silkstone Four-foot, the Swilley, and Walker's or Thorncliffe Thin.

Park Gate Coal.—Throughout the district with which we are at present concerned the coal, generally known by the name of Park Gate, consists of several layers of coal separated by dirt partings, but its main feature is the layer of semi-anthracitic coal, termed "hards," which it contains.

The analysis of a sample of this coal from Aldwarke Main Colliery gives:—ash 1·37, sulphur 0·95, and the yield of coke 65·25 per cent.

In the neighbourhood of Sheffield the following may be taken as a typical section of this coal:—

	Ft. In.	Ft. In.		Ft. In.
Coal	—	0 6	to	1 0
Shale and Underclay	0 3	—	„	0 11
Coal, Hards	—	3 0	„	4 0
Soft Carbonaceous Matter... ...	0 $2\frac{1}{2}$	—		
Coal	—	0 11		
Soft Carbonaceous Matter... ...	0 6	—		
Shaly Coal	—	0 5		
		4 10		

At Wharncliffe Silkstone Colliery the average section is as follows:—

	Ft. In.	Ft. In.
Soft Coal	1 6	—
Underclay and Coal	—	1 $10\frac{1}{2}$
Shale and Iron Pyrites	—	0 10
Coal, Hards	2 7	—
Underclay	—	0 7
Soft Coal	1 5	—
	5 6	

From Dodworth to Cawthorne the Park Gate Coal consists of two bands of coal separated from each other by from 3 feet to 9 feet of shale and underclay, and this form is maintained very constantly throughout this district. North of Cawthorne the coal is still further divided, and represented by several layers of coal, and it is only about Emley, where the coal known as "Old Hards" begins to be worked, that the seam becomes of importance again.

The strata which contain the Park Gate Rock, Fenton's Coal and Black Mine Ironstone, Flockton Coals, and Tankersley Ironstone, are a most interesting group; but as I have already communicated a paper on the Flockton group to the Midland Institute, in which these beds are more or less fully described, it is perhaps not necessary for me to refer further to them here.

Swallow Wood Coal.—The Swallow Wood Coal is most constant and regular in its occurrence throughout the whole of the coal-field. It is known under different names, and exists in different forms; but its relative position in relation to the Silkstone and Barnsley Coals does not admit of any doubt arising as to the horizon in which any of its representatives occur.

At Car House Colliery the section is that given below :—

	Ft.	In.	Ft.	In.
Hard Coal	3	0	—	
Soft Clay	—		0	2
Soft Coal	2	3	—	
Underclay	—		1	0
Coal	1	0	—	
	6	3		

The analysis of an average sample of the coal from this colliery shows it to contain :—ash 1·78, sulphur 0·89, and the yield of coke amounts to 61·39 per cent.

From Sheffield northwards to Barnsley the upper beds are very continuous, and form the source from which the workable coal is obtained. The Hard Coal ranges from 2 feet to 3 feet, and the Soft Coal from 1 foot to 2 feet 3 inches in thickness. Formerly the Swallow Wood Coal was not much worked, but it is now beginning to be much more sought after.

North of Barnsley these two beds of coal are separated from each other by some 10 or 11 yards of strata. Here they are known under the names of the Netherton Thick and Netherton Thin Coals. Although apparently two distinct seams, they are in reality the representatives of the Swallow Wood Coal.

Barnsley Coal.—The Barnsley Coal is probably the most notable of all the coal seams in the district, both as regards quality and thickness. Within the district from Sheffield to Barnsley the layers or sub-divisions of which the seam is made up are very much alike in thickness and in character, as will be seen from a comparison of the sections given below :—

Kiveton Park Colliery.

	Ft.	In.
Top Softs	0	8
Hard Coal	0	5½
Soft Coal	0	4¾
Main Hard Coal	1	7½
Soft Coal	0	6
Branch Coal	0	4
Soft Coal	0	11¼
	4	11

Aldwarke Main Colliery.

	Ft.	In.
Top Softs	1	8
Hards	3	9
Bottom Softs	1	4
	6	9

Elsecar Collieries.

	Ft.	In.
Tops	1	6
Softs	1	6
Hards	4	6
Softs	1	6
	9	0

Monckton Main Colliery.

	Ft.	In.
Top Softs	4	3
Spavin and Bind	21	2
Soft Coal	0	11½
Hards	2	6
Soft Coal	2	0½

Section (North End) Woolley Edge Tunnel.

	Ft.	In.	Ft.	In.
Coal			1	7
Grey Shale	0	7		
Coal	0	2		
Grey Shale and Underclay	2	6		
Nodular Ironstone ...	0	2		
Grey Shale	0	11		
Black Shale	0	2		
Underclay	0	4½		
			4	10½
Coal	0	1½		
Underclay	0	3		
Black Shale	0	0½		
Coal, hard and bright ...	1	5		
			1	10
Underclay	0	4		
Coal and Black Shale ...	0	6		
Underclay and Black Shale	0	6		
			1	4
Coal	0	7		
Black Shale	0	1½		
Coal	0	5		
Soft Parting	—			
Coal, dull and hard ...	1	4		
			2	5½
Underclay			1	6
Black Shale and Coal			0	2½
Coal			0	6
Underclay and Black Shale ...			0	6
Coal			0	2

Denaby Main Colliery.

	Ft.	In.
Day Bed	1	2½
Dirt	0	6
Middle Bed ... ... } Low Bed ... ... }	1	5
Clay Seam Dirt ... ... } Clay Seam Coal ... ... }	1	4
Hards	3	2
Bottom Softs or Slotting Coal ...	2	6
	10	1½

Oaks Colliery.

	Ft.	In.
Day Bed	1	4
Dirt	—	
Middle Bed ... ... } Low Bed ... ... }	1	3½
Clay Seam Dirt	0	2
Clay Seam Coal	0	10
Hards	2	3
Bottom Softs or Slotting Coal ...	2	3½
	8	2

Wombwell Main Colliery.

	Ft.	In.
Day Bed	1	3
Dirt	—	
Middle Bed	0	6½
Low Bed	0	9½
Clay Seam Dirt	0	1¼
Clay Seam Coal	0	6
Hards	2	9
Bottom Softs or Slotting Coal ...	1	11¾
	7	11

Mapplewell Collieries.

	Ft.	In.
Day Bed	1	3
Dirt	0	3
Middle Bed	0	8
Dirt	0	3½
Low Bed	1	5
Clay Seam Dirt	0	6½
Clay Seam Coal	0	8
Hards	2	8
Slotting Coal	1	6

These sections show that, although there are variations in the thickness of the individual layers of coal and dirt which constitute the Barnsley Coal, the seam maintains a very decided similarity of character throughout the Sheffield and Barnsley district. The Top Softs varies from 7 inches to 1 foot, the Hards from 2 feet to 3 feet 2 inches, and the Bottom Softs from 4 inches to 1 foot 9 inches. This coal seam, in the district to the south-east of Sheffield, differs somewhat from this general type, and is thinner. North of Masborough the divisions of the seam into Top Softs, Hards, and Bottom Softs, is typical of the constant and regular nature of the coal over an extensive area from Rawmarsh to Elsecar. At Aldwarke Main Colliery the Top Softs is 1 foot 8 inches thick (generally, however, the upper layer is divided into Roof Coal and Top Softs, and the average thickness of these two layers is 2 feet 5 inches), the Hards is 3 feet 9 inches, and the Bottom Softs 1 foot 4 inches thick. In the neighbourhood of Barnsley the full thickness and excellent quality of the coal is maintained. The Top Softs is often sub-divided into three divisions termed respectively Day Bed, Middle Bed, and Low Bed. A band of inferior coal and clay now lies between the Top Softs and Hards. Here the Top Softs averages 3 feet 6 inches, the Hards 2 feet 6 inches, and the Bottom Softs 2 feet in thickness, the total thickness of the coal ranging from 8 feet to 10 feet. In the district of Mapplewell and Woolley several additional partings of shale or dirt occur between the different layers of coal. These partings are only thin at first, but northwards they increase in thickness to such an extent that the coal becomes of very little value, and the most valuable part of the Barnsley Seam, viz., the Hards, apparently disappears altogether. The section which is exposed at the north end of Woolley Edge Tunnel furnishes an excellent example of this, as it shows the three bands of coal separated by shales, coals, and underclays, to such an extent that they are practically worthless.

It is the semi-anthracitic nature of that portion of the Barnsley Coal, known as the Hards, which renders the seam so very valuable. This part of the coal is suitable for use in blast furnaces, and yields an excellent steam coal for locomotive and marine engines. The Hard Coal is made up of dull and bright layers of coal, semi-anthracitic and bituminous in character, therefore the coal is not so difficult to kindle as a pure anthracite, while there is abundant carbon to ensure a high heating power. The Soft Coal is principally used for household purposes, and the best quality finds a ready sale in the London market. This layer burns to a light, powdery white ash.

Strata between the Barnsley and Wathwood Coals.—South-east of Sheffield the five seams of coal in the strata lying between the Barnsley and Wathwood Coals are the Foxearth, Sough or Yard, Furnace, Kent's Thin, and High Hayles Coal. North of Sheffield these seams are represented by the Two-foot or Half-yard, Abdy or Winter, Beamshaw, Kent's Thin, and Kent's Thick Coal. Several of these seams are of very fair quality, but hitherto they have only been worked to a small extent. When the thicker seams of coal have been to some extent exhausted these beds will, no doubt, in many cases yield a large supply of good coal. They are fully described in the Geological Survey Memoir on the Yorkshire Coal-field.

Wathwood Coal.—The Wathwood Coal has not been very extensively worked, but the quality of the coal is good, and it runs up to 3 feet in thickness, so that it is certain to become of importance in the future. In those districts where the Woolley Edge Rock lies immediately above the coal the workings will be subject to a heavy feed of water from the overlying sandstone.

Woolley Edge Rock.—One of the most important and conspicuous members of the Coal-measures in the Barnsley district is the sandstone of Woolley Edge. This rock does not exist in the country between Hemingfield and West Melton, for in that locality the measures above the Wathwood Coal are known to consist of shales alone. But it appears suddenly on the north side of the valley of Elsecar Brook, where it forms an escarpment at once bold and striking. From its first appearance the Woolley Edge Rock continues to occur north-westward with regularity as far as Normanton and Pontefract.

In the southern portion of the area occupied by the Woolley Edge Rock, the sandstone is coarse in texture and massive in appearance. Occasionally, as north of Dillington, it is very coarse, and contains so great a number of large pebbles of white quartz that it assumes the character of a conglomerate. In fact, it possesses many of the distinctive characteristics of an extremely coarse grit. Its thickness is variable, and sometimes it consists of alternations of sandstone and shale. At Monk Bretton it is a massive rock 131 feet 3 inches thick, while at Swaithe Main Colliery, and in the shaft for the Oaks Colliery at the Oaks Quarry, it is more or less split up by intercalated shale bands of variable thickness.

Swaithe Main Colliery.

	Ft.	In.	Ft.	In.
Sandstone	21	0		
Shale	15	0		
Sandstone	21	0		
Shale	24	0		
Sandstone	18	6		
Shale	4	0		
Sandstone	3	0		
Shale	2	0		
Sandstone	6	2		
			114	8
Shale	11	0		
Wathwood Coal... ...	—			

Oaks Colliery, Shaft at Oaks Quarry.

	Ft.	In.	Ft.	In.
Gritstone	15	8		
Sandy Shale and Sandstone	19	10		
Gritstone	41	0		
Black Shale and Underclay	2	8		
			79	2
Shale	37	4		
Wathwood Coal... ...	—			

Distinguished by its massive and coarse character, the Woolley Edge Rock occupies a most conspicuous place, and forms one of the grandest features in the district from Wombwell Park to the broad valley of the River Calder. Here its character changes suddenly. The town of Wakefield stands upon a sandstone which lies on the same horizon as, and is evidently the equivalent of, the Woolley Edge Rock. At Wakefield, however, the sandstone is finely-grained and flaggy, and very different in appearance from the typical grit of Woolley Edge. Through Milnthorpe to Wakefield the rock is fully developed, but in several instances west of Wakefield

it has been proved to be entirely wanting. In the neighbourhood of Newlands the sinking of the St. John's Colliery proved quite an unusual thickness of sandstone above the Wakefield Muck Coal. The upper beds of the rock seemingly occupying the stratigraphical zone usually occupied by the shales and the coal known as the Newhill Coal.

The cutting for the Midland Railway, near Normanton, at the south-western end, is cut wholly through sandstone, but as the section is followed to the north-east bands of shale gradually come in, and as gradually thicken out, occupying more and more space until the sandstone is entirely replaced by shale.

There is a great contrast between the regularly laminated, closely-grained, and thickly-bedded pale bluish sandstone of Normanton, when first taken out of the quarry, and the white, coarse grit of Woolley Edge. This lithological change in the texture and appearance of the rock illustrate in a very forcible way the folly of attempting to classify any particular rock by texture, colour, or general similarity of character alone. The Wakefield sandstone has not the faintest resemblance lithologically to the Woolley Edge Rock, and yet they are without doubt one and the same continuous bed of sandstone.

Treeton or Oaks Rock.—A compact and massive sandstone occurs at Treeton, and the Red Rock of Rotherham rests unconformably on a continuation of the same sandstone west of the village of Aston. It is here, however, very thin and shaly. This sandstone increases in thickness to the north-west, is estimated to be about 100 feet thick, and to lie about 850 feet above the Barnsley Coal. North-west of Catcliffe a bed of sandstone is observed above the Treeton Rock, and another and higher rock occurs north-west of Brinsworth. This group of sandstones must die out rapidly, for at Holmes Colliery shales and thin coal seams occupy the zone of these sandstones. At Kilnhurst, however, there is again a thick bed of sandstone above the Swinton Pottery Coal. In the railway cutting at Kilnhurst Station the rock consists of irregular bands of sandstone with lenticular beds of shales, and small masses of coal-pebbles of shale also occur in the sandstone here. At Swinton Park Gate Colliery the thickness of the Oaks Rock is given as follows:—

Oaks Rock.

	Ft.	In.
Sandstone	59	0
Shale	3	0
Sandstone	31	9

In several instances the shale is much thicker, and in other instances the sandstone has various beds of shale interstratified with it. The section of the sinking of the Ardsley Pit, Oaks Colliery, furnishes an excellent example of the character of this rock, where the shale bands are numerous:—

Ardsley Pit, Oaks Colliery.

	Ft.	In.		Ft.	In.
Soft Sandstone	2	6	Blue Shale	2	8
Shale	2	4	Sandstone...	18	6
Shale and Sandstone ...	8	6	Soft Shale...	1	3
Shale	21	1	Sandstone...	11	11
Sandstone...	9	9	Sandstone and Seams of Coal	2	8
Shale	0	1¼	Sandstone...	5	0
Sandstone...	1	10½	Shale	3	10
Shale	0	1½	Sandstone...	1	4
Sandstone...	14	10½			

In a quarry south of Shepcote, Monk Bretton, the sandstone and shale bands are interstratified in a manner very similar to the above, while in another quarry close by there is not a single shale band in existence.

From Kilnhurst to Barnsley the Oaks Rock makes a most conspicuous feature, and is well exposed throughout its whole range. The sandstone is very extensively worked in the district around Oaks Farm, near Barnsley, whence it takes its name. It is excellent in quality, and used for building purposes of all descriptions.

Northwards from Monk Bretton the Oaks Rock does not form such a marked escarpment as it does to the south of Barnsley, but it can still be easily recognised. The less distinct nature of the physical feature is likely due, in some measure, to the shale beds which are known to occur in the sandstone throughout this district. Through Chevet Park to Walton it again assumes a more distinct form, and appears in force at the north end of Chevet Tunnel, in the Midland Railway cutting south of Sandal and Walton Station, in the cutting between Agbrigg and Oakenshaw, Lancashire and Yorkshire Railway, and in the quarries on Heath Common. It seems to disappear east of Sharlston Colliery, is hardly recognisable at Whitwell Main Colliery, is altogether extinct at Featherstone Colliery, and at the Prince of Wales Colliery in Pontefract Park. The rock which is observed at Ackton lies on the same stratigraphical horizon as the Oaks Rock, and can be followed north-eastwards nearly to Glasshoughton Colliery. It is exposed in the cutting for the Lancashire and Yorkshire Railway south-west of this colliery, but almost immediately dies out again, as no corresponding sandstone was sunk through in the shafts for the Glasshoughton Colliery. This is the third occasion on which the sandstone has been proved to be replaced by shales—1st, in the neighbourhood of Holmes Colliery, near Rotherham; 2nd, in the vicinity of Featherstone and Pontefract; and 3rd, at Glasshoughton.

This sandstone, when present in a fully developed form, contains very large quantities of water, sometimes yielding as much as 3,000 gallons per minute.

The measures above the Oaks Rock are very variable. In the south they occasionally contain a coal of some importance, and here and there the sandstones are sufficiently well marked to enable them to be followed for short distances. The most regular of the sandstones is the Upper Chevet Rock, which lies below the Shafton Coal, and from its first appearance about a mile south-west of Thryberg, runs on continuously to Royston Station, north of Barnsley.

About Royston these sandstones disappear, and three seams of coal, each about 3 feet thick, exist in the strata between the Oaks Rock and the Shafton Coal. These coals are named the Sharlston Top, Sharlston Low, and Sharlston Yard Coal.

Shafton or Nostel Coal.—As the Shafton Coal this seam is known to occur regularly over a large area on the eastern side of the coal-field, from Denaby to Felkirk. At Harlington, where this coal was formerly worked, it was said to be as much as 5 feet thick; and at Billingley, there were from 3 feet 7 inches to 4 feet of good coal, and from 1 foot to 7 inches of bad coal.

This coal, which has been worked to some extent all along the outcrop to Shafton, varies in thickness from 4 feet to 5 feet.

At Ellis Lathe Colliery the detailed section is as follows:—

	Ft. In.	Ft. In.
Coal	0 4	—
Dirt	—	0 2
Coal	3 6	—
Dirt	—	0 1
Coal	0 6	—
	4 4	

As an engine coal, for which purpose it is extensively used, the quality is excellent. It also commands a local sale for household purposes. At the present time there are several collieries working this seam alone.

Strata above the Shafton Coal.—The strata above the Shafton Coal contain several sandstone bands and thin seams of coal. Some of these sandstones are extremely local in their occurrence, as for example, the Thryberg Hall Rock and the Havercroft Rock, which, though largely developed in one locality soon die away and disappear altogether. One of the seams of coal, namely, the Herringthorpe Coal, seems to exist very continuously northwards from Rotherham. However, very little definite information is to be obtained about this seam, either from natural exposures or from the district where it is said to have been worked. On the other hand, the Brierley Rock and the Wickersley Rock are two very strong and conspicuous sandstones. They both cover large areas in the districts where they exist, the former about Houghton Common and Brierley and the latter about Wickersley and Ravencroft.

Red Rock of Rotherham.—The very striking character of the red sandstone, known as the Red Rock of Rotherham, attracted the attention of all the earliest observers. Originally it was classified by Mr. W. Smith as equivalent to the Woolley Edge Rock, and is so represented on his Geological Map of Yorkshire. This correlation is not tenable. Coming down to later times, it was considered to belong to the Permian Formation, and was classified with the Lower Red Sandstone. This view has also been discarded, and I think rightly so.

In West Cumberland the Whitehaven Sandstone very much resembles the Rotherham Red Rock, both in appearance and character. Generally the colour of the Whitehaven Sandstone is a greyish purple; but it ranges from grey to dark red, the texture is coarse, and the structure massive. It also contains a large quantity of Coal-Measure plants, many of which are in so fragmentary a condition as to be indeterminable; but undoubted specimens of *Lepidodendron*, *Sigillaria*, *Calamites*, and *Stigmaria* have been found in it. This sandstone is, moreover, unconformable to the Coal-Measures in West Cumberland, and probably marks a transition period between the true coal-bearing beds and the Magnesian Limestone, Red Shales, and Red Sandstone of Permian age. The fossil remains would seem to indicate that the Whitehaven Sandstone is more intimately related to the former than the latter.

In Ayrshire, Scotland, there is also an upper unconformable division of the Coal-Measures corresponding in many respects to the Red Rocks to the south-east of Rotherham.

The cutting for the Midland Railway, about a mile south of Masborough Station, gives a section showing a coal and sandstone overlying the Red Rock. These beds resemble ordinary Coal-Measures. The section of the sinking at Shireoaks proved 57 feet of shales, sandstones, and two seams of coal overlying the Red Rock in that locality. Hence we conclude that this sandstone occupies a position similar to the Whitehaven Sandstone in relation to the true Coal-Measures.

Explorations and workings at some of the South Yorkshire collieries enable the unconformity of the Rotherham Red Rock to be satisfactorily established.

A drift was cut from the Holmes Colliery southwards, and the calculations made from the results obtained from this exploring drift give the distance from the base of the Red Rock to the Barnsley Coal at Boston Castle to be 450 yards.

East of Treeton the Red Rock is some distance above the Treeton Sandstone; but at Aston the former rests on the latter, then comes down gradually over it until both sandstones are nearly on the same level. Here the Red Rock is only 200 yards above the Barnsley Coal.

At Kiveton Park Colliery the distance of the Barnsley Coal below the Red Rock is 410 yards, while at Shireoaks Colliery it is only 358 yards.

This change in the position of the Red Rock, notwithstanding the variable nature of sandstones in general, is not one that was likely to take place if this sandstone

was regularly interstratified with the other strata—especially the great change between Treeton and Aston. As the distance of the Red Rock from the very regular position occupied by the Barnsley Coal in this locality varies to such an extent, and occurs so very irregularly from place to place, it has been conjectured that the irregularity arises from the sand, now constituting the Red Rock, having been deposited in a hollow, out of which the Coal-Measures originally existing had been denuded prior to the deposition of the sand. At Shireoaks the Red Rock is overlaid by Magnesian Limestone, but there are no means of determining how far it may extend to the south-east. North of the Don Valley no trace of any corresponding sandstone has been found. If it originally extended farther, it must afterwards have been denuded away; but it is more than probable that the scooped out basin in which it was deposited did not extend much farther north.

The PRESIDENT—It will be almost impossible to attempt anything in the shape of discussion to-day, but Mr. Russell is kind enough to say that if any member has any particular point that he wants illustrating, if he will write to himself or the Secretary with those points, they will be considered by him and attended to at the next meeting in April. Or if there is any gentleman has any special question that he wants to ask at this moment he can at once ask it, so that we can get on to the next papers.

Mr. J. DAGLISH—I have been asked to move a vote of thanks to Mr. Russell for his interesting contribution to the Transactions. It will have a special interest to gentlemen in this district, but we can all gather that it contains most useful information and great research. Coming from a gentleman so thoroughly at home in the district I am sure it will be not only of great value to us personally, but will add to the character of our Transactions.

Mr. A. M. CHAMBERS—I have pleasure in seconding the resolution. I do so most heartily, for I am perfectly sure the paper will be of great interest and importance to this district.

The resolution was carried unanimously.

Mr. G. BLAKE WALKER read the following paper on "Coal-getting by Machinery":—

COAL-GETTING BY MACHINERY.

By George Blake Walker, F.G.S., Assoc. M.I.C.E.

The revival in the coal trade, coupled with the fact that the best and thickest seams of coal are becoming rapidly exhausted in many parts of the country, is causing attention to be directed to thinner seams which hitherto have not been considered worth working. In the same connection interest in coal-getting machines is reviving, and I understand the North of England Institute has appointed a committee to report on coal-getting machines, and the extent to which they are now being made use of.

There is an ever-increasing tendency, which is characteristic of our times, to substitute machinery for human labour in almost all the severe forms of toil; and there is a natural and growing indisposition on the part of the rising generation to accept the same measure of exhausting labour which their forefathers bore. Not only are the working hours being constantly reduced, but the amount of physical effort put forth is probably very much less, and in some industries the amount of skill displayed is less also. This certainly seems to be true of coal mining, as those who have some knowledge of mining in past times can bear witness, and it is a tendency which inevitably presses in the direction of the substitution of machinery, wherever possible, for human labour. Once there was a jealousy of machinery among the miners themselves, but that has now completely disappeared, and they are now distinctly favourable to its introduction; taking care, however, that the reduction in the severity of their labour shall not bring them any reduction in the actual money value of it. I know of no case where the working miner has not been better off in pocket in consequence of the introduction of machinery than he was before.

Some years ago I read a paper on the same subject as this before the Midland Institute, but I feel considerable difficulty in doing justice to it at the present time owing to the very considerable development which has taken place (especially in America) during the last few years. Probably the machine which is destined to be the model type of the future has yet to be designed, and no doubt it is in the direction of machines actuated by electricity that the most successful machines must be looked for. It was once remarked to me by one of our Past-Presidents that coal-getting machines were a *mechanical* but not an *economic* success. I do not myself endorse this dictum, but it probably represents the general feeling of mining engineers on the subject. But what may not be an economic success under certain conditions of trade, may become so if a change in those conditions takes place; and what was of doubtful advantage this time last year may present a very different aspect at the present moment.

In dealing with a subject with which all mining engineers are familiar, it is desirable to go straight to the points on which information is really desired, and these I presume are the practical results obtained from independent experience.

Coal-cutting machines have hitherto been used for three purposes: 1st, for heading; 2nd, for holing; and 3rd, for bringing down the coal. The last of these is so large a subject in itself, and one which may be regarded to a great extent separate, that I do not propose to touch upon it in the present paper.

The only machine which has yet been introduced successfully to deal with heading is the Stanley boring machine, upon which a paper was read in the spring of 1888 before the Chesterfield and Midland Counties Institute by Mr. Reginald Stanley, of Nuneaton, the inventor. The writer had a few weeks ago the opportunity of seeing one of these machines at work at Mr. Stanley's colliery, and was much struck with the practical and satisfactory way in which it worked.

The Stanley heading machine consists of a pair of vertical engines, placed at the bottom of a narrow frame, actuating, by means of gearing, a central shaft which carries a cutter bar of the size which the heading is to be driven. The cutter bar consists of a massive casting parallel to the face to be excavated, and carrying two brackets having a projection of two feet, to which are fixed the cutting knives or chisels. The excavation made is annular, and leaves in the centre a core of coal, which, if not broken in the process of cutting, has to be wedged down by hand. In most seams, however, a large part of the coal would break off and would be removed without the necessity of stopping the machine. The machine itself is so narrow that there is room for the men to pass from the back to the front, and to throw back the coal. The following is a quotation from Mr. Stanley's paper above referred to, from which the peculiarities of its construction will be understood:—

"The engines on the 5 feet machine are 9 inches diameter and 9 inch stroke, gearing to the central shaft, carrying arms and cutters, 13 to 1. Pressure of air required in our slate coal, 20 to 40 lbs., working with 20, but *better* with 40 lbs.

"The cutters are made of cast steel, a particular brand, which we have (after making many trials) found to stand the best. They are tempered about the same as ordinary picks. As to the shape, the square, wide points standing well out are found to be the best. The first were made more of a plough shape, but as soon as the point was gone they rubbed on the back, and unless the machine was firmly fixed, the pressure at the face pushed the machine back, or failing that stopped the arms. A V or diamond-shaped cutter was next tried, but this inclined the cut to one side or the other of the groove, according to which side of the V edge was sharpest. The fitting and setting of the cutters require care, but by the help of a gauge they can be set as accurately as the teeth of a circular saw. (They are usually set to cut an annular groove, 3 inches to 3½ inches wide.) The right or left direction of the cut is regulated by the side screws, which also serve to set the frame in the position required. The men prefer to have the machine leaning somewhat to the cylinder side, as it gives more room for passage at the other side and in no way affects the working of the cutters. The side wheel holds the cylinder side up as it is run forward. In dip headings, such as we are driving, the frame with engine part is moved forward between the cuts by the force of its own gravity; all there is to do is to release the screw pins and open the split nut, when it advances steadily along the shaft to its position ready for another setting.

"For level or rising heads, and from trials we have made (since commencing to write this paper), for dip headings as well, we have lately introduced another mode of advancing the frame (see drawings, Nos. 6 and 7, Figs. 1 and 2, Plate XIV.) It consists of a cog wheel having a screw-threaded brass bush fitted into its boss, which works in the threaded part of the central shaft. This is held to the frame and driven from a sliding cog on the crank shaft when the cutting gear is thrown out, and this set in motion, the frame is caused to advance on the shaft (to advance it the full length requires little less than a minute), or the shaft is caused to retire in the frame, according to which of the two parts of the machine is fixed in the heading. The direction of the machine is thus kept between the cuts, and all is ready for cutting as soon as the screw pins are fixed. The cog

wheel with threaded bush is held to the frame, and as the cutting proceeds, being prevented from turning the central shaft, is caused to advance in the frame, thus taking the place of the split nut. By regulating the direction of the central carrying wheels, the frame is kept upright whilst being advanced, doing away with the necessity for the side wheel, as the back struts and the arms at the front hold the machine.

"The manner of working is as follows:—The machine being up to the face of the heading and fixed ready for work, one man takes his place at the left side with a raker, and as the cuttings are brought back by the scrapers, easily rakes them towards him as the arms are revolving, passing them to the man at the back as opportunity presents itself. When the arms have advanced sufficiently to allow of it, he moves from the left to the right side of the machine in front of the cylinders, and changing his raker for a shovel, throws the cuttings along the left side to the back of the machine, where the man at the handle loads them into a tub or throws them still further clear of the machine. Small lumps that fall from the face whilst the cutting is proceeding, are dealt with in the same manner without stopping the arms, but for big lumps, or when the core breaks down (which occurs ordinarily within a distance of a foot or so), the air is shut off whilst the coal is disposed of. If men mean work this is soon done, and upon the energy displayed at this point depends, to a great extent, the distance cut, for the machine does not take long to do its part of the work. The arms having worked out their full length (between three and four feet), the engines are stopped, screw pins slacked, split nut thrown open on its hinges—or in the case of the new arrangement, the propelling wheels are put in gear—and the frame is run forward and fixed for another cutting.

"The time occupied in doing this with the split nut gearing varies from five to ten minutes, and with the new arrangement for propelling something less; the actual time occupied in moving the frame forward being less than a minute, and, with the advantage of more regularity and steadiness, the setting and fixing for another cutting occupies less time than with the split nut.

"To men new to the work, it must be confessed the machine and its operations appear highly dangerous, and there is generally a difficulty in getting them to take their place at the side of the machine when it is cutting, but they soon get used to it, and like the work, finding it is quite as safe as, in fact, safer than heading by hand. The machines cannot fall over under any circumstances, and there is no danger of the roof falling on them. The complete safety of the machines is shown by the fact that during our many experiments, and after more than two years' working with different machines, we have not had the slightest personal accident with them.

"In respect to the quality of work done, the roads are straighter than can be driven by hand labour. The sight is kept without difficulty, and requires much less attention on the part of the management."

Mr. Stanley states that the progress made with his machine may be considered to be about one yard per hour, and it did this in my presence. On a trial of twenty-four hours such a machine has cut 64 feet 6 inches. Generally speaking, I think Mr. Stanley's heading machine may be regarded as a thoroughly practical and successful contrivance, and one which very successfully solves the problem of rapid progress, and an improved sample of coal from the headings driven by its means.

Mr. Stanley states that he has recently made a machine to cut through hard or stony material, having a much stronger and slower cut, and one to cut away the whole face of the heading, and pass the slack back automatically by mean of a frictionless worm trough.

Mr. J. W. Galloway, of the Trabboch Colliery, Ayrshire, gives me the following table of the relative cost of heading with Stanley's machine, as compared with hand labour in the splint seam at Trabboch :—

RELATIVE COST PER YARD.

Cutting with Machine—	s.	d.	*Cutting with Hand—*	s.	d.
Actual cost per yard over three weeks in February	10	5	Actual cost per yard	3	6
Round coal per yard produced, 1 ton 14 cwts. @ 1s. 8½d. per ton	2	10½	Round coal produced per yard, 4 tons @ 1s. 8½d. per ton ...	6	10
Dross, 5 cwts. = 1 hutch @ 2d.	0	2	Dross, 2 hutches at 2d. each ...	0	4
	13	5½		10	8
Actual cost per yard over two weeks in March	6	5			
Round coal per yard produced, same as above	2	10½			
Dross, do.	0	2			
	9	5½			
Actual cost per yard for cutting mine	12	0	Estimated cost per yard for cutting mine	19	0

I am not aware of any other machine which has been made a practical success for heading, and I therefore now turn to the machines whose functions it is to hole or undercut the coal, and of which a very considerable number have been invented and tested in the past.

A machine for holing should comply with the following conditions :—

1. It should be *light* and *strong*. It must be light to be manageable by two men working in a confined position; and strong so as not to be liable to serious injury from falls of stone or coal, or rough usage.

2. It should be *narrow*. It is important that the space between the timber and the face should be as small as possible, especially where the roof is not strong.

3. It should be *simple*. The machines have to be worked by unskilled men, and they should be able to keep it in order themselves without having constantly to call in the assistance of a fitter.

4. It should clear its own cut.

5. It should be able to cut into the straight face at the start without having a hole made for it.

6. It should have a *reserve of power*. This is desirable to enable the machine to cut through nodules of pyrites or other exceptionally hard substances.

7. The cutting tools should be simple, and easily changed and sharpened.

Among the most successful compressed air machines may be mentioned Mr. William Firth's "Pick" (a machine introduced thirty years ago, and still at work at the West Ardsley Colliery, near Leeds); Baird's endless chain machine (Gledhill's patent improved), which has been largely used by Messrs. Baird in their coal and ironstone pits, and at some other pits in Scotland (see Plate I.); the Rigg and Meiklejohn; the Gillott and Copley; and the Winstanley disc machines.

The last three machines are of what is usually termed the rotary type, that is, they undercut the coal by means of chisels set in a circular wheel. The special feature in each case may be briefly stated. The Rigg and Meiklejohn machine cuts from front to back and thus carries its *débris* into the cut, which has, therefore, to be cleared separately. It cuts, however, on the level of the foot of the seam.

The Gillott and Copley machine works in the opposite direction, and so brings out its *débris* if the cut is above the floor. If below, a certain portion of the excavated material is carried back into the cut, but this can be obviated to a considerable extent by means of a guard placed in rear of the wheel. The gearing of the Gillott and Copley machine is 5 to 1, a greater ratio than the Rigg and Meiklejohn. It is a lighter machine, and therefore handier for removal, and is capable of cutting harder material.

The Rigg and Meiklejohn machines in operation at Whitehill Colliery, near Edinburgh, as to which I have been kindly furnished with information by Mr. Archibald Hood, have coupled cylinders, each 7¾ inches diameter by 10 inches stroke, working direct on crank. On the crank shaft is a spur wheel, which works into a disc, 2 feet 10 inches diameter. The engines are driven at a speed of about 160 strokes per minute, and the disc 70 revolutions per minute. One of the machines travels along a line of walls at an inclination of from 9 degs. to 14 degs. and cutting regularly from 140 to 150 yards in a shift of nine hours.

As the haulage gearing on the machine is not sufficient to haul the machine up the walls, a back balance, consisting of a few loaded hutches (about three tons) on an incline, and attached to machine by a ½ inch wire rope, is used for hauling it up. The wire rope alone retards the motion of the machine sufficiently when coming down the walls.

The full complement of men for working this machine is five, but it is occasionally done with four: one driving and lifting rails behind machine, one guiding and laying rails in front, one removing machine holings from underneath coal, one setting props, and one stripping loose coal from face.

The machine cuts in the coal to an average depth, on the whole run, of 2 feet 6 inches. It cuts with least difficulty when the line of faces are on half end and half plane of the coal. When the faces are on the plane of the coal, the coal breaks off the face, and falling on top of disc retards the motion of the machine very much. The coal averages 2 feet 3 inches in thickness, with 9 inches "falling" on top, and a strong sandstone roof. The output of coal is about 10 cwts. per yard. The contractor is paid at the rate of 6½d. per ton of coal and dross.

The air-compressing engines on surface consist of a pair of coupled engines, 20 inch cylinders and 4 feet stroke, and a pair of air cylinders, 24 inches diameter, placed immediately behind steam cylinders. The air-pressure varies from 55 to 65 lbs. The compressors supply air for three coal-cutting machines. The air is forced into two air receivers, about 27 feet by 5 feet, and then through 6 inch pipes to bottom of shaft, where two 4 inch pipes branch off. The air from above machine is conveyed through about 500 fathoms of 4 inch pipes, and about 100 fathoms of 3 inch pipes, and then 2¼ inch flexible hose to machine.

The length of time and disc lasts varies so much that it is not possible to give an average.

The average length a machine works before being brought to the surface for thorough overhauling is about six months.

The seam of coal in which the machine cuts is the Jewel seam, varying in thickness from 2 feet 3 inches to 2 feet 9 inches, and the inclination varying from 1 foot in 4 feet to 1 foot in 6½ feet.

The machine cuts in the bottom of the coal, and as it can travel in any height not less than 21 inches, there is no necessity for lifting pavement to provide more height.

The width between the face of the coal and the edge of the waste, which must be left clear to allow the machine to pass, is 4 feet.

The machine cuts alternately in opposite directions.

The Gillott and Copley machine (of which there are a large number at work in various parts of the country) are those which have been for many years past in use at the Wharncliffe Silkstone Collieries, where they were ultimately selected after a trial of most of the machines in existence at the time. The latest and most improved machines have cylinders 9 inches diameter by 10 inch stroke. The pinion on the crank shaft is geared into a spur wheel upon an intermediate shaft, which again works into the cast steel cutter wheel by means of a bevel pinion. The ratio of gearing amounts to about 5 to 1, and as the engines run about 150 strokes a minute, the revolutions of the cutter wheel will be about 30 per minute. The cutter wheel itself is a cast steel or cast malleable iron disc, 4 feet diameter, having on its outer periphery a series of boxes, in which the chisels are secured either by means of studs or by a pin dropped into a slot in the chisels. In the older wheels the chisel boxes are all inclined in one direction, but in the newer ones at opposite angles to allow of the reversing of the machine. Inside the chisel boxes is a tooth-rack, into which the bevel pinion, already referred to, works. The whole cutter wheel is carried by a triangular bracket, the centre of which is a broad bearing of phosphor bronze. The chisels used are of two kinds, single and double, placed alternately. The single chisels have a quarter of an inch lead of the double chisels, and the latter, when new, have a width over all of nearly 3 inches.

The machine is drawn forward by a wire rope which coils upon a drum, revolved by means of a ratchet wheel and pawl, which can be regulated to take one or more teeth according to the hardness of the material to be cut.

The Winstanley machine is not, so far as I know, at present in use. It has many good points, especially that of being able to cut into the face, which the other two machines are not as yet arranged to do; but the machine as hitherto designed has been very short of power, and has consequently not succeeded in cutting anything very hard. The oscillating cylinders are probably a mistake, but the idea is capable of considerable improvement, and may do good work in the future.

In Baird's machine the cutting is done by an endless chain with cutters attached, driven round a jib or arm, which extends underneath the coal. The machine draws itself above the coal face. The jib projects underneath coal from 2 feet 9 inches up to 5 feet, as required, and cuts itself in at the start. About 100 yards are cut 2 feet 9 inches deep in 8 to 10 hours. Two men and a boy are required to attend the machine, which travels or cuts in either direction. The undercut by this machine is only 2¼ inches high.

These are the machines which have been the most successful in this country, and perhaps of those actuated by compressed air in use in America, the Legg coal-mining machine best merits attention. This machine is different in construction from any of the English machines which we have noticed. It consists of a bed frame, occupying a space 2 feet wide by 7 feet 6 inches long, composed of two steel channel bars firmly braced, the top plates on each forming rocks with their teeth downward, into which the feed wheels of the sliding frame engage. Mounted upon and geared to this bed frame is a sliding frame upon which are mounted at the rear end two small engines with cylinders 5 inches by 5 inches, from which power is transmitted through gearing to the rack, by means of which the sliding frame is fed forward. Upon the front end of this sliding frame is mounted a cutter bar, held firmly by two solid steel shoes with suitable brass boxes. The cutter bar contains twenty-six steel bits, made of tool steel, held in place by set screws. When the cutter bar is revolved, these cutters cover its entire face. The cutter bar is made to revolve by an endless steel chain from the driving shaft, and, as it is revolved, it is advanced by the above mechanism into the coal or other material to be undercut to the desired depth. The feed is thrown on and off by means of a lever. The cut under the coal,

5 feet by 3 feet 6 inches, is made, and the cutter bar withdrawn, in from four to six minutes. The weight of this machine is about 10 cwts. It requires no road, and can to some extent be used in heading. The *débris* from the cut is removed by scraper chains.

Hitherto we have dealt exclusively with machines actuated by compressed air, but within the last year or two a new and more economical power has become available in electricity, and, although this is not yet provided in a form where it can be used with absolute safety in gaseous mines, it possesses many advantages over compressed air where the conditions are suitable for its employment.

A machine, which the members of the Midland Institute have lately had an opportunity of inspecting at work, has been very successfully tried at Messrs. T. R. and W. Bower's, Allerton Main Collieries, near Leeds. This machine is working in a seam of coal 5 feet thick, where it cuts in a band of shale 1 foot from the floor. It consists of a Goolden motor specially designed with a drum armature with a special wrapping, the copper wires being embedded in and covered by the iron. The motor actuates a serrated cutting bar, which makes 600 revolutions a minute, when 6 horse-power or a current of 30 ampères is developed. In actual work, however, some 30 per cent. more power is actually used. Generally speaking, it may be stated that the horse-power developed is 6 and in hand coal 9; the depth of cuts 3 feet 6 inches. The groove is 5 inches deep in the front and 3 inches at the back. The patentees state that the speed of cutting may be put at 30 yards an hour, and that on one occasion 125 yards were cut in 5 hours, including the time of getting the machine ready and clearing away for fillers.

Messrs. Bower and Co. inform me that in ordinary working they average 150 yards per machine per shift of 8 hours. The conditions under which this machine is working are however favourable, and can hardly be compared with the performances of machines holing in strong stone. They also claim the following advantages for this machine :—

1. That the cutter is not liable to be damaged by the fall of the coal, but neither is this the case with the rotary air machines.

2. That the power is easily and cheaply conducted to the machine, the cables being simply fixed to the roof or wall, and are easily transported, and offer no impediment to the working of the mine.

They state that the loss of power, in cable unusually adopted, is about three horse-power per mile, but that this can be reduced, if necessary, by using larger cables.

I should have wished to have dealt adequately with the work of machines actuated by electric power (which in non-gaseous mines seems likely to be cheaper and more convenient than compressed air), but I have not had the advantage of any personal experience with electrical coal-cutters myself. The following statements, for which I am in great measure indebted to Mr. Snell will, I think, be found to summarise most of what has been done in this direction.

Messrs. Bower's is, I believe, the only attempts to apply electricity to coal-cutting in Great Britain; there are, however, several at work in America. The "Sperry coal digger" consists of a pick, actuated by a spring, so constructed that a series of rapid blows can be given in a straight line. The electric motor winds up the spring. Mr. Snell, who saw one of these coal diggers at the Paris Exhibition, writes that he was much struck with its workmanlike appearance:—

"It appears to be admirably adapted for very hard seams, gritty dirt, or fire-clay containing iron balls. The gearing is so arranged that the blow can be administered through any distance up to the full throw of the crank without causing any shock to the motor or gearing, beyond that due to the vibration of the

carriage. The direction of the blow is controlled by the miner. The force of the blow is governed by a powerful cylindrical spring. The rate of delivery can be varied by a reducing switch attached to the starting gear. The distance through which the pick travels is automatically regulated, and depends on the resistance met with."

I need not describe the construction at length. The machine appears to be well designed, and is said to stand the hardest usage. The following figures, furnished by the Sperry Coal Digger Company, will give an idea of the working capabilities of their machine:—

In a 6 feet seam 110 tons were undercut in 10 hours by one man and one assistant.

Depth of undercut	4 feet.
Length of face	120 „
Horse-power required on surface	2·55.
Number of blows per minute	200 to 250.

The "Bain" coal-cutting machine has some points of resemblance to Messrs. Bower's, the action of the cutting bar constituting the chief difference. Mr. Snell kindly sends me the following information respecting it:—

"It appears that the rotating cutter bar is fed forward from the frame by a chain and sprocket wheel. The front part of the frame is held down by a pointed iron bar attached firmly to the main carriage, and adjusted by a wheel and screw. The makers give the electrical energy required as 18 horse-power, *i.e.*, 60 ampères and 225 volts. The motor then develops 15 B.H.P. It is said that the machine makes a cut 5½ feet deep and 3 feet wide in 3½ minutes. Six of these cuts can be made per hour, allowing ample time for withdrawing, shifting, and fixing the machine, so that with a 5 feet seam, about 200 tons of coal can be undercut in a working day of 10 hours."

Lastly, a very successful machine appears to have been invented by a Mr. F. N. Lechner. It appears to be a very light and handy machine, the weight being between 8 and 9 cwt. The motor is detached from the machine, and is mounted on a truck and connected with the machine by a ⅝ inch rope belt, running in V shaped grooved pulleys. The manner of getting the coal is not mentioned, but its performances appear to have given great satisfaction.

From this very brief and imperfect statement it is evident that in America far more has been done in the direction of electrical coal-cutting than has been accomplished in this country, doubtless owing to the high price of labour on the other side of the Atlantic, and to the mechanical ability for which the Americans are distinguished. There can be little doubt, however, that the conditions of the problem have been successfully solved on both sides of the water, and we may look for a very rapid development of machine-mining in the near future.

There are other machines besides those I have mentioned, but they have not, to my knowledge, been largely made use of, and time will not permit of a description of them. The function of all these machines is to undercut the coal in the same way as has hitherto been done by hand labour, but with more rapidity and with less waste of coal. So long as seams of fair thickness were worked, and skilful holders were obtainable, there was little advantage to be looked for in introduction of machinery, but as thinner seams were opened out and the skilled workmen became rarer, the amount of waste caused made it absolutely necessary to adopt some expedient, as under the old system half the output of a tender seam would pass through the screens. The improved size of the coal is always the chief advantage to be looked for from the adoption of machinery, but in equity there ought to be a further saving on the cost of production after allowing for plant, wear and tear, and power.

It now remains to deal with a question of great interest, viz., a comparison of the actual cost of coal-cutting by hand and by machine, based not upon theory, but upon experience. I have endeavoured not to exaggerate the amount of saving effected by the use of machines, and I have taken the figures of twelve months ago, when wages and materials were lower than at present, as I think it will be far more useful to understate than to overstate the advantage, but it may be assumed that better results than those which follow may be anticipated under exceptionally favourable circumstances and very perfect arrangements.

The table on the following page has been carefully prepared, and if proper allowance is made for special circumstances it may be of service in a general consideration of the subject.

As it would be tedious to read all the figures in the table, I may say that I have assumed that in a 3 feet seam with a favourable holing material, the quantity of slack made when the holing is done by hand would be (say) 35 per cent., and when done by machine 20 per cent. A considerably lower percentage might be claimed for the machine and ought to be realised, but I prefer to take figures which are not too favourable to the machine. In a seam, 1 foot 6 inches thick, I have taken 45 per cent. for hand labour and 30 per cent. for machine, as in the case of so thin a seam as this the coal will be more broken from the difficulties inseparable from getting and filling than in the former case. These figures will, of course, depend upon the hardness of the seam, but will, I trust, be sufficiently close for our purpose.

The work assigned to each machine per day of sixteen hours is taken at 200 yards where the holing material is favourable, and is reduced to 160 and 120 where it is harder. Where it is possible to always have a clear face and an unobstructed course for the machine to forge ahead without delay, and where the coal stands firmly and does not fall into the way of the cutters, probably twice as much work as I have stated could be accomplished.*

* Experiments with Messrs. Bower's electric coal-cutting machine at West Allerton Colliery, on January 15th, and with a Gillott and Copley compressed air machine at Wharncliffe Silkstone Colliery, on January 17th, 1890.

West Allerton Colliery.						Wharncliffe Silkstone Colliery.					
Length cut.	Time.		Length cut.	Time.		Length cut.	Time.		Length cut.	Time.	
Yards.	Min.	Sec.	Yards.	Min.	Sec.	Yards.	Min.	Sec.	Yards.	Min.	Sec.
1	2	0	9	16	0	1	1	35	15	23	0
2	4	0	10	17	45	2	2	15	16	24	55
3	6	0	11	19	45†	3	3	5	17	26	25
4	7	30	12	24	0	4	4	35	18	27	50
5	9	0	13	26	15	5	6	25	19	29	35
6	10	30	14	28	30	6	8	0	20	31	15
7	12	15	15	31	30	7	9	45	21	32	45
8	14	0	16	33	45	8	11	20	22	34	15
						9	12	55	23	35	40
						10	14	45	24	37	15
						11	16	35	25	38	50
						12	17	55	26	40	15
						13	19	35	30	52	0
						14	21	20	34½	60	0

† Machine stopped two minutes here.

Machine commenced cutting at 11·8 p.m., and finished at 12·28 a.m., cutting 46 yards in eighty minutes, including five minutes total stoppages for running rope out, etc.

Comparison of the Relative Cost of Coal-getting by Hand and by Machine.

	In a Seam 3 Ft. Thick.			In a Seam 2 Ft. 6 In. Thick.			In a Seam 2 Ft. Thick.			In a Seam 1 Ft. 6 In. Thick.		
	Nature of Holing.			Nature of Holing.			Nature of Holing.			Nature of Holing.		
	Favourable.	Hard.	Very Hard.	Favourable.	Hard.	Very Hard.	Favourable.	Hard.	Very Hard.	Favourable.	Hard.	Very Hard.
Price for getting coal by hand per ton	1/6	1/8	1/10	1/10	2/0	2/2	2/5	2/8	2/10	3/2	3/6	3/10
Percentage of slack by hand	35	40	45	40	45	50	42	46	50	45	50	55
Do. do. machine ...	20	20	20	20	20	20	25	25	25	30	30	30
Average selling price per ton round (including nuts), at 6s. per ton, hand	4/9·3	4/7·2	4/5	4/7·2	4/5	4/3	4/6·3	4/4·7	4/3	4/5	4/3	4/1
Do. Slack, at 2s. 6d. „ machine	5/4	5/4	5/4	5/4	5/4	5/4	5/1½	5/1½	5/1½	4/11½	4/11½	4/11½
Price for filling out coal when coal is holed by machine, including getting bottom up	1/0	1/1	1/2	1/3	1/4	1/5	1/7	1/8	1/9	2/0	2/1	2/2
Yards holed by each machine per day of 16 hours	200	160	120	200	160	120	200	160	120	200	160	120
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Holed by 8 machines per week, say ...	8,000	6,500	4,900	6,900	5,400	4,100	5,400	4,300	3,270	4,000	3,250	2,450
Do. do. in 48 weeks, say	384,000	312,000	235,200	331,200	259,200	196,800	259,200	206,400	156,960	192,000	156,000	117,600
Cost per ton (based on previous estimate) for holing by machine.—Labour (1 man at 6s. per day, 1 at 5s. per day)	1·6	1·9	2·6	1·8	2·4	3·0	2·4	2·9	3·9	3·1	3·9	5·1
Allowance for first cost of plant (£900 per annum)	·6	·7	·9	·6	·8	1·1	·8	1·0	1·3	1·2	1·5	1·9
Do. power (£1,210 per annum)	·8	·9	1·2	·9	1·1	1·5	1·1	1·4	1·9	1·5	1·8	2·5
Total cost of coal-getting by machine	1/3·0	1/4·5	1/6·7	1/6·3	1/8·3	1/10·6	1/11·3	2/1·3	2/4·1	2/5·8	2/8·2	2/11·5
Saving as compared with hand labour	3·0	3·5	3·3	3·7	3·7	3·4	5·7	6·7	5·9	8·2	9·8	10·5
Saving in yield of coal (value) ...	6·7	8·8	11·0	8·8	11·0	1/1·0	7·2	8·8	10·5	6·5	8·5	10·5
Total saving	9·7	1/0·3	1/2·3	1/0·5	1/2·7	1/4·4	1/0·9	1/3·5	1/4·4	1/2·7	1/6·3	1/9·0

Still I find that on an average if 160 yards are accomplished day by day when allowances are made for removal from place to place, and for hindrances of various kinds, it is as much as can be fairly assumed. At a colliery at Airdrie, in Scotland, where the Rigg and Meiklejohn machine is holing in a seam 2 feet 6 inches thick (cutting in the coal), I am informed that as much as 220 yards is frequently holed in a shift of eight hours, four men being employed: two with the machine, one in advance laying road, and one in the rear spragging up the coal and clearing out the groove. Actual experience, however, points to 100 yards per eight hours shift as being a satisfactory performance when the ordinary conditions of work in a coal face are in force. There are a thousand little hindrances and delays which occur to a greater or less extent in every mine; and in mines where the roof requires constant attention, considerably less than 100 yards per shift will be accomplished. It rarely happens that a pit can be so well organised that the machine never has to wait for the coals being filled out. The more perfectly such organisation is effected, and the more regularly the machines are enabled to keep at work, the better will be the results which will be obtained. With regard to the allowances made for plant and power, these are based upon the figures which I give later.

The general result shows a saving ranging from 9½d. to 1s. 9d. per ton, of which two-thirds roughly is obtained from the reduction of small made where machines are used.

The practical points which arise, apart from the physical conditions of the seam to be worked, are :—

1. The necessary plant and its cost.
2. The work which may be expected from machines.
3. The method of working.

1. Dealing with these questions in order, and very briefly, it may be at once admitted that everyone of them is a question of circumstance, and can only be answered with precision when a particular installation is before us. It may be convenient, however, to assume a certain quantity of plant, and assign a value to it for the purpose of forming an estimate, leaving each person to modify that estimate as his own particular circumstances may require.

The power to be employed is the first question to be settled. There are really but two which are actually in the field—compressed air and electricity. Compressed air is an exceedingly uneconomical power. It is subject to continued loss from the moment of compression to the moment of use. If 40 per cent. of the power put into the steam cylinder issues from the air cylinder into the mains it must be considered an exceedingly good result. But the air is subject to enormous resistance in the pipes, which are usually of great length, to leakage at hundreds, perhaps thousands, of joints, so that if 20 per cent. can ultimately be utilised it is all that can be expected. Much may be done by using mains of large size, and by careful attention to them, to save power, but this means money, though it is money well spent. Electricity gives very much better results, but is open to some objections, the principal of which is the sparking, which, though it may be reduced, cannot be wholly got rid of.

The first cost of a coal-cutting plant, in which the motive power is compressed air, may be calculated as follows :—

If the cylinders (2) of a coal-cutting machine are 8 inches diameter by 10 inch stroke, and the cut-off is at three-quarters, the number of strokes 130 per minute, and the number of cubic inches of compressed air per minute will be about 196,033·5 (say 200,000).

An air-compressing engine, having air cylinders 30 inches diameter by 5 feet stroke, and running 35 revolutions per minute, will deliver about 1,781,287·2 cubic

inches of compressed air at 50 lbs. pressure per minute. Allowing for a loss of pressure from leakage and pipe resistances, we may take the same quantity at the machines, but reduced to 30 lbs. pressure. A pair of 30 inch by 60 inch compressors would, therefore, drive eight machines of the size above-mentioned with something to spare. This, then, gives us a basis for calculating the first cost of the plant. This I will assume to be as follows :—

Air compressing engine (pair 30 inches by 60 inches) ...	£1,300
Foundations and house...	500
Five boilers (Lancashire) and seating	2,000
Say eight coal-cutting machines @ £150 each	1,200
Mains and laying, say	1,000
Total	£6,000

Coming now to the cost per ton of machine work, we have to make a suitable allowance for the fixed plant, for which purpose we may take 15 per cent. of

the above figure of		£6,000
viz.: £900		900
Add labour charges at surface—		
Two enginemen at 30s. per week	£150	
Four stokers at 25s. per week	240	
Fitting work	50	
Stores (compressors and machines)	170	
Fuel, 3,000 tons at 4s.	600	
		1,210
Add underground labour charges—		
Machinemen, 5,300 yards per week at 3½d.	£3,490	3,490
Total for one year ...		£5,600

By estimating the average amount of cutting which a machine may be expected to do in a week, and multiplying by (say) forty-eight weeks, we obtain a divisor by which to divide the above sum, and estimate the cost per yard.

For the purpose of comparing the cost of an electrical plant, performing an equal amount of work with the compressed air plant which has already been given, I have prepared the following from data supplied to me by Messrs. Immisch and Company and Messrs. W. T. Goolden and Company. The number of machines to be worked is the same as in the previous estimate, viz., eight, and it will be seen that the total capital outlay amounts to £4,212 and £8,837 respectively, as compared with £6,000 for compressed air.

	Immisch & Co.	Goolden & Co.
90 horse-power engines	£500	...
160 horse-power engines	...	£1,020
Two Lancashire boilers	650	...
Three do.	...	975
Engine house and fittings	450	450
Dynamo	500	...
Two dynamos	...	680
Eight electrical coal-cutting machines	1,600	5,200
Switches	56	56
1,500 yards of No. 19/14 cable at 3s. per yard ...	225	225
2,000 do. 7/16 do. 1s. do. ...	100	100
1,500 do. intermediate do. 1s. 9d. do. ...	131	131
Total	£4,212	£8,837

2. In considering the amount of work which may be expected from machines when worked upon a regular system it is most misleading to base a calculation upon the best results obtained during a short trial. Of course, the actual distance undercut in a given time depends chiefly on the nature of the material in which the holing is done, and I have seen machines cut in favourable material at the rate of 50 yards an hour, which, if continued for 8 hours, would be 400 yards per shift. The Gillott and Copley machine is extensively used at the collieries of the Nitshill and Lesmahagow Coal Company in Scotland. and is there working seams which occasionally reach as small a section as 3 inches, and which certainly could not by any possibility be worked by hand. This is, however, combined with 6 or 7 inches of ironstone. The holing is done in a bastard fire-clay with ironstone balls. The machines here do about 80 yards in a shift of 10 hours, but in some other seams which are worked at this colliery the same machines do as much as from 150 to 180 yards in the same time.

3. The method of working the machines is as follows:—Two men are usually employed with each machine. It is questionable whether it is economical only to employ two men with each machine. If three or four are employed, the extra progress made will probably more than pay the extra wages. The function of one is to drive the machine, clear away the excavated material, and sprag up the undercut coal. This is the leading man, and he has the responsible charge of the machine. The second man lays the road in front. The road consists of three 15 feet lengths of stiff rails. A 20 pound bull head rail is sufficient, but if a flat-bottomed rail is used a greater weight per yard than this will be required, as the rail will be less stiff. The sleepers are made in a particular way and are of two kinds—joint sleepers, where the ends of the rails are brought together and held firm by screws, and light-rolled intermediate sleepers between the joints. The driver takes up a pair of rails as soon as the machine has cleared the joint, and without stopping the machine passes the rails and sleepers over to his companion in front, who lays them in advance. The Gillott and Copley machine is propelled by means of a light steel rope which winds upon a drum, passing round a snatch block in advance, the drum being actuated by a ratchet wheel connected with the crank shaft of the machine. The teeth of this ratchet are very small, and a slot on the crank shaft enables one or more to be taken per revolution, so that the amount of progress can be nicely regulated to the nature of the material in which the holing is to be done. The air is conveyed to the machine through 2 inch india-rubber pipes, which are attached to the metal pipes. The hose is 4-ply, capable of resisting a pressure of 60 lbs. on the square inch, and is protected against abrasion by a web of cord known in the trade as marline. This marline protects the india-rubber from friction, and when worn through the pipes can be sent to the works and a fresh envelope of marline put upon the hose, provided the hose is withdrawn from work before it has itself been injured. As the hose pipe is expensive, costing £6 13s. for 60 feet, great care should be taken of it. If carefully used, a length of hose ought to last twelve months.

The system on which a bed should be laid out for the use of machines must, for the ordinary type, necessarily be longwall, and if it were possible to have a series of walls in continuation of each other, as for instance four sides of a rectangle or the eight sides of an octagon, the arrangement would be most perfect, for then the machine could work round successively without the necessity of removing from point to point; but as the conditions obtaining in mines will not always allow of such an arrangement the nearest possible approach to it should be made. It is not necessary to enter into this question in the present paper, because it is purely a matter of local circumstance. Generally speaking, a long continuous face will give

before starting a full day's work was seldom got, which eventually caused the stoppage of the place. The cutting in the foregoing instance was done with two shifts of eight hours each, and two men on each shift, exclusive of drawers.

Another place was started parallel to it, and in first week 8 yards were cut, second week 41 yards, and third week 35 yards, same shifts and men. Here, again, gas got troublesome, and the machine was turned to hole through on previous tunnel, and in doing so another difficulty was experienced in getting the core down. The two previous tunnels had been cut at right angles to plane of coal, but in the latter case it was cutting on end of coal, and in this way only 18 yards per week were cut.

Cutting to the rise was again resumed, and at right angles to plane of coal, and had only proceeded 35 yards when a down step of 25 fathoms was struck, but as an upstep was expected, which would level out another seam, it was decided to continue cutting stone with the machine, and in this it cut 215 feet at the rate of 8 yards per week, with usual number of men. The stone in this mine was a dark shale with ironstone balls.

The machine is again at work in splint seam and cutting on end of coal from 20 to 25 yards per week, but gas is again getting troublesome; although a ½ inch cock is kept continually blowing it is inadequate to cope with quantity given off.

No timber has been used in any of the tunnels, whereas by hand labour in the ordinary way two props per yard would have been required.

In cutting by hand there is no difficulty with gas, and the men work with naked lights.

RELATIVE COSTS PER YARD.

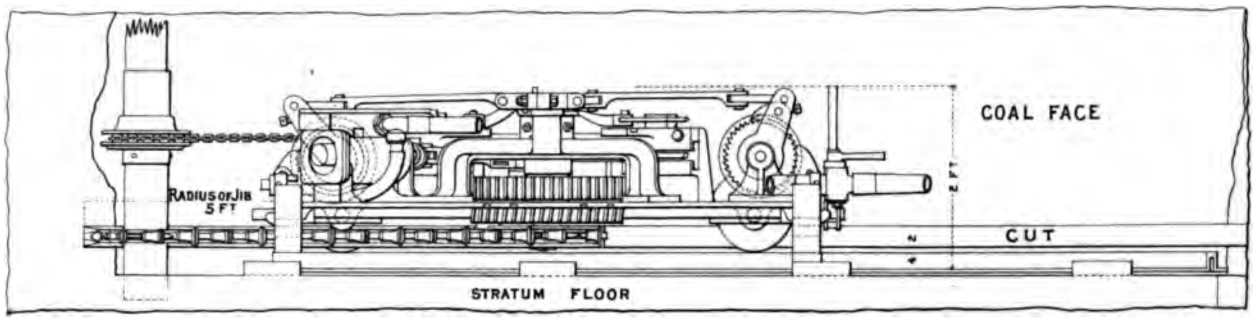
Cutting with Machine—	s.	d.	*Cutting with Hand—*	s.	d.
Actual cost per yard over three weeks in February	10	5	Actual cost per yard	3	6
Round coal per yard produced, 1 ton 14 cwts. @ 1s. 8½d. per ton	2	10⅓	Round coal produced per yard, 4 tons @ 1s. 8½d. per ton ...	6	10
Dross, 5 cwts. = 1 hutch @ 2d.	0	2	Dross, 2 hutches @ 2d. each ...	0	4
	13	5⅓		10	8
Actual cost per yard over two weeks in March	6	5			
Round coal per yard produced, same as above	2	10⅓			
Dross do.	0	2			
	9	5⅓			
Actual cost per yard for cutting mine	12	0	Estimated cost per yard for cutting mine	19	0

In comparing the quantities of coal, etc., produced by either method, it must be remembered that the area of way cut by the machine is 5 feet diameter, and by hand 9 feet by 5 feet.

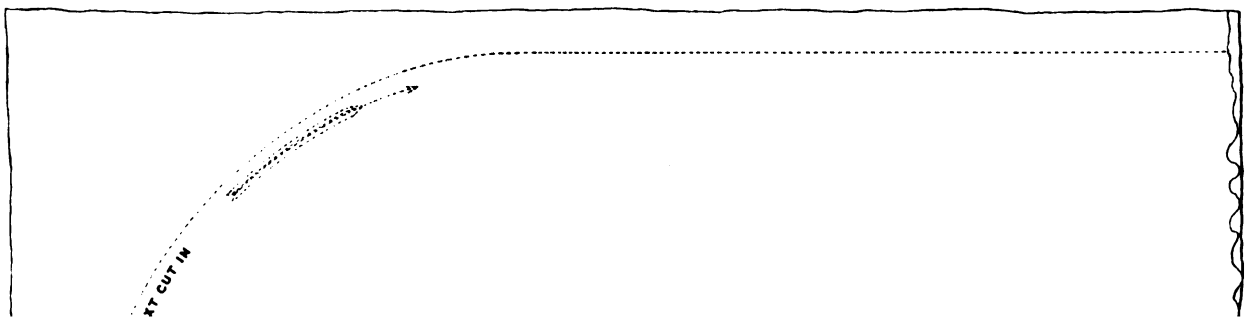
The PRESIDENT—As in the previous paper, it will be impossible for us to attempt anything in the shape of a long or conclusive discussion. As most of you

To illustrate Mr. G. B. Walker's Paper "on Coal Getting by Machinery."

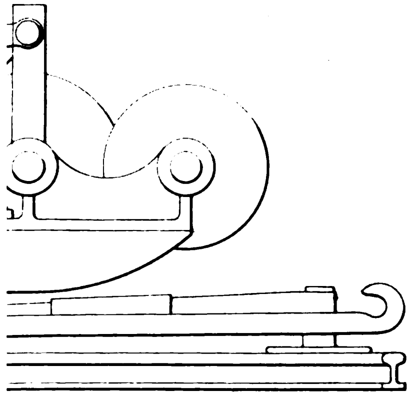
Baird's Coal Holing Machine.

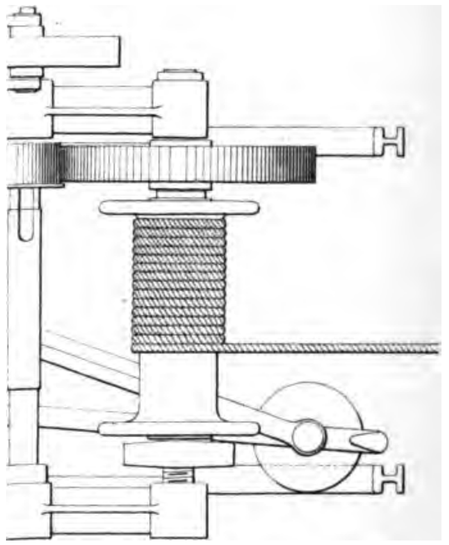


ELEVATION



nery.



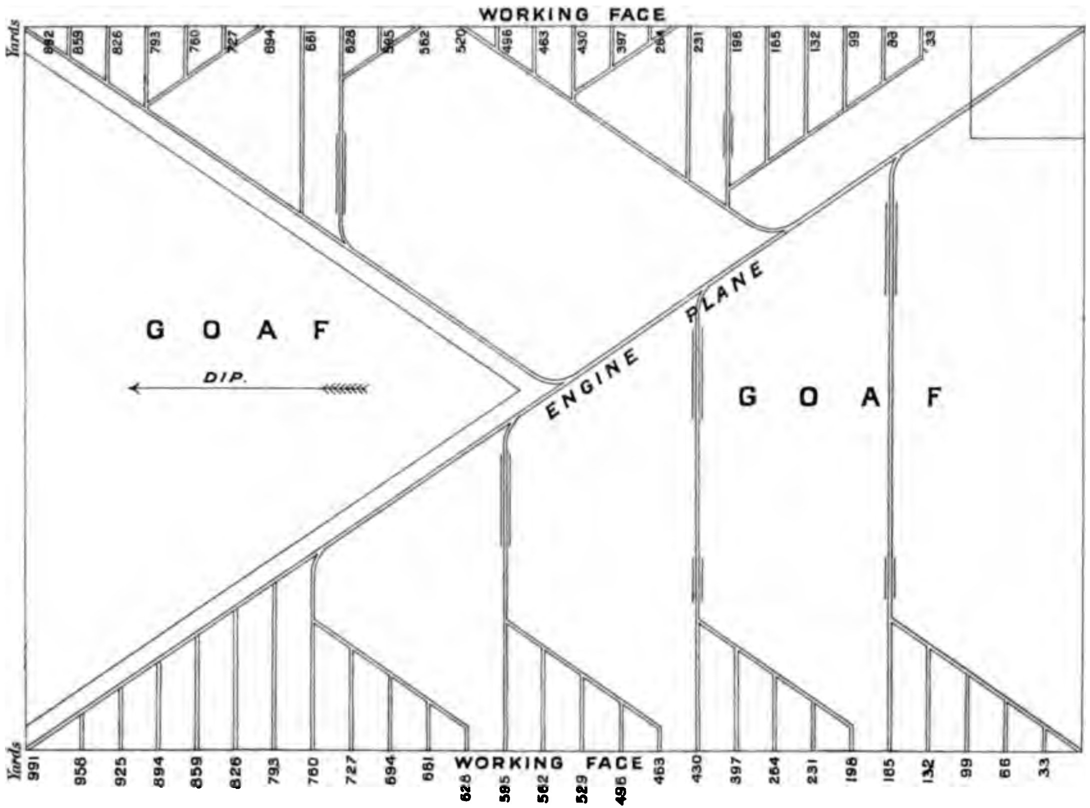


Andw Reid, Sons & Co Lithos. Newcastle.

To illustrate Mr. G. B. Walker's paper "On Coal Getting by Machinery."

Sketch Plan for Dip District worked by Machines.

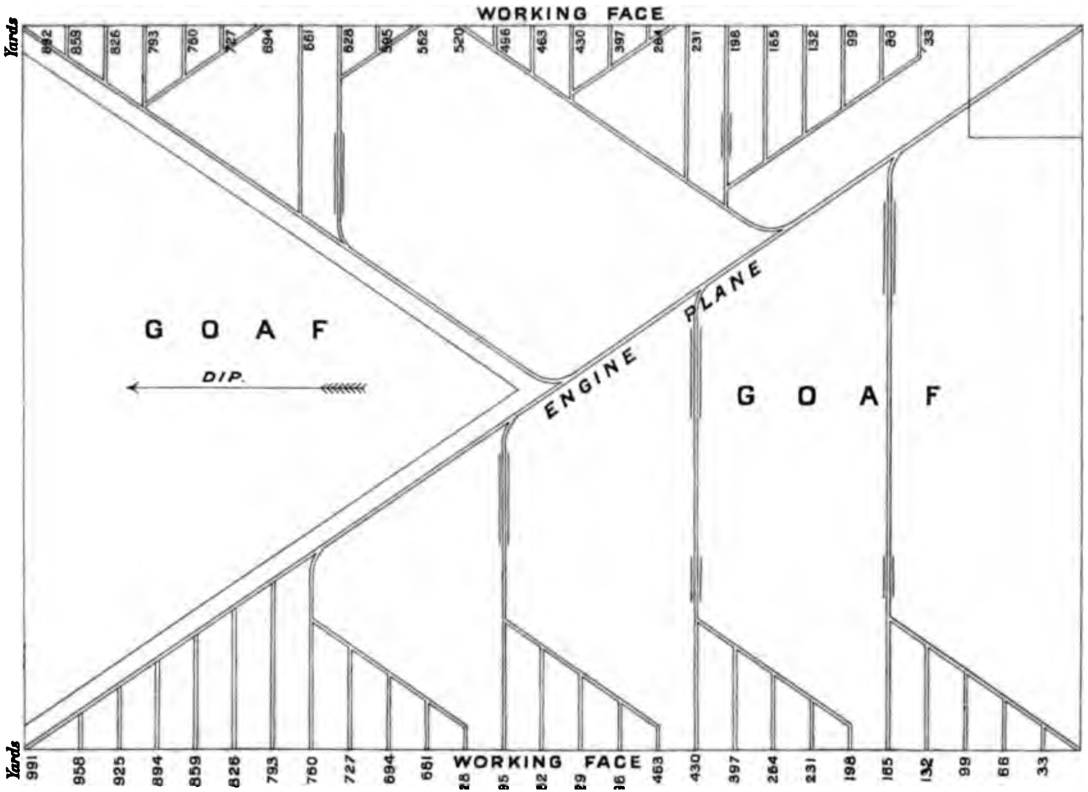
COAL GOT ON END.



To illustrate Mr. G. B. Walker's paper "On Coal Getting by Machinery."

SKETCH PLAN FOR DIP DISTRICT WORKED BY MACHINES.

COAL GOT ON END.



THE DISTRIBUTION OF ELECTRICAL ENERGY OVER EXTENDED AREAS IN MINES.

BY ALBION T. SNELL, ASSOC. M. INST. C.E.*

Some three months ago the writer read a paper before the Lancashire Branch of the National Association of Colliery Managers at Wigan. The subject then chosen was practically the same as that under consideration now, but it was only treated in an elementary manner, and, further, the distribution of energy over extended areas was not discussed. The following paper is an attempt to give a solution of the problem, in sufficiently general terms, to cover the range of work likely to occur in ordinary mining practice.†

At Wigan the writer felt that electricity as a motive power in mining operations was not properly appreciated by the majority of mining engineers. The subject was but little understood, and very vague notions existed as to the use and possible limits of electrical plant. An effort was therefore made to describe in a crude manner the application of electricity to the transmission of power, and electricity was roughly defined as a means by which energy could be transmitted from a place where it could be cheaply generated to a place where it could be usefully spent.

An electrical plant was discussed in its essential details, and its component parts compared with their analogues in a compressed air system. Some plants, illustrative of every-day mining work, were described in detail, and exhaustive efficiency tests were given. The greater part of the paper was of an elementary character.

Since then, however, the subject has received considerable attention in mining circles, and favourable expressions of opinion have been given by prominent engineers. The results obtained in pumping and hauling at St. John's Colliery, Normanton, and in numerous other pits in Great Britain, Germany, France, and America have at last been recognised as commercial successes. And it may now be fairly assumed that electricity is one of the recognised means of transmitting power in mines. The writer thus feels justified in carrying the subject a stage further. He proposes to examine the different methods by which electricity can be applied to mining operations on a large scale. For it is evident that, if electricity is to be applied to general purposes, so as to thoroughly compete with compressed air systems, the power must be distributed in such a way that a number of motors can be supplied off the main cables.

With the single exception of the dip pumps at Andrew's House Pit (p. 26 of Wigan paper) no attempt has been made in Great Britain to lay out for underground work a parallel-motor system, *i.e.*, one in which a number of motors can be coupled at pleasure to the mains, without reference to each other or to the source of supply.

(Since writing this paper arrangements have been made to extend the plant at St. John's Colliery. The addition will be made with a view of a complete parallel system in the future.)

This is so, not on account of any electrical difficulty, but simply from commercial considerations. The cautious conservatism of which the British as a race are justly proud has usually limited the installations to a single motor and the necessary dynamo. Hence the electrical engineers have chosen the cheapest and

* See Part 2 of the Proceedings, page 139.
† In order to make the subject clear to mining engineers, the effects of induction and the reaction of the armature on the field magnetism are neglected.

most suitable method of design for a single plant, viz., a series-wound dynamo and motor. This arrangement gives, in addition to simplicity, the important property of nearly constant speed of the motor, if the dynamo be kept running at a uniform rate. This elementary system of installation has done yeoman service in the past, and will still be of use for isolated plants; but the time has come when a more general solution of the problem of electrical distribution in mines is required.

Fortunately, there is no need of special experimenting in this direction. The experience gained *above ground* in the supply of power by electric motors is sufficient to satisfy the most exacting conditions of *underground* work. And it is only necessary to modify the methods hitherto used to suit the new conditions.

Electrical distribution of power is accomplished in two distinct ways. The first is made by a continuous current, *i.e.*, the current is assumed to flow from the positive brush of the dynamo to the negative brush. The second is made by alternating currents, *i.e.*, the flowing of current is regarded as alternating in direction, the number of reversals varying from about 40 to 100 per second in different systems.

Hitherto, transmission of power has, with a few exceptions, only been accomplished commercially by continuous currents. The writer will therefore first discuss the systems involving direct currents.

Readers of the Wigan paper will recollect that the rate at which electrical work is performed can always be expressed as the product of two quantities, symbolised by C × E, where C equals the number of ampères flowing in the mains, and E

Fig. 1.

equals the number of volts at which the current is supplied. If C × E represents the quantity of energy supplied by a dynamo to a system of motors, it is clear we can vary the value of the work at any moment by changing both the values of C and E; or by keeping C constant and varying E; or by retaining the value of E and varying C. These three methods are in general use, and may be distinguished under the following heads:—

1.—*Single transmission* by series-wound dynamo and motor. Both C and E are variable.

2.—*Constant current transmission*, applicable usually to one dynamo and a number of motors, all running in series with each other. C is constant and E variable.

3.—*Constant potential transmission*, comprising in its simplest form one shunt or compound-wound dynamo, and a number of series, shunt or compound-wound motors. E is constant and C variable.

To properly understand these methods of distribution, which are likely to obtain in the immediate future of electrical distribution of power in mines, it will be necessary to distinguish between the different types of machines.

A dynamo or motor is said to be wound in series when the armature is coupled in series with the field windings (Fig. 1). If the field coils be joined as a shunt to the brushes, then the machine is said to be shunt-wound (Fig. 2); and if a combination of the two windings be adopted, the machine is said to be compound-wound (Fig. 3). The writer does not intend to discuss the necessary magnetic and electrical conditions applicable to each case, as this belongs to machine construction, and

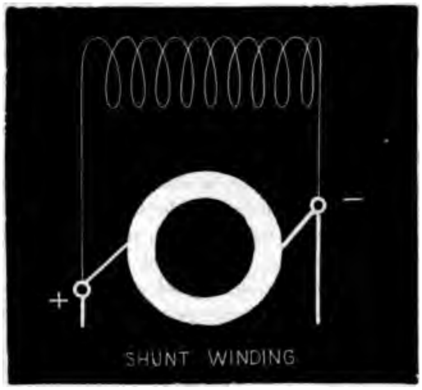


Fig. 2.

is outside the present subject. The characteristics of each system of winding must, however, be understood in order to appreciate their particular capabilities.

The *series-winding* is chiefly applicable to a pair of machines. It is most useful where the motor shaft is required to run at a constant speed irrespective of the load. This winding also gives the greatest possible torque or turning moment at starting.

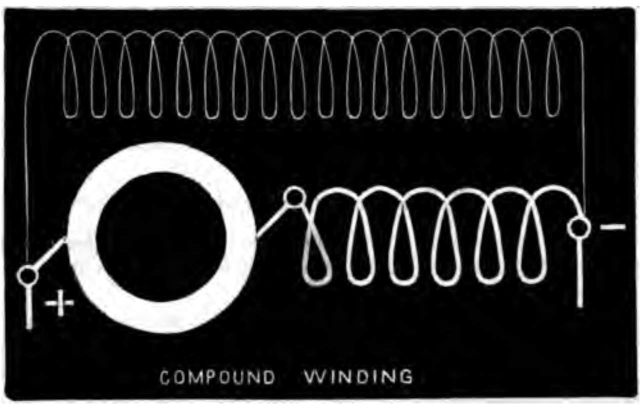


Fig. 3.

These are most important points in many cases, notably the pumping and hauling plant at St. John's Colliery (p. 13, Wigan paper), in which the motors have to start against the load of the column and the weight on the two ropes, and also have to maintain approximately the same speed whether the hauling ropes are on or not. With the series system, two or more pairs of machines may be coupled to the same work mechanically, but the electrical connections must be independent. The Nor-

manton plant is arranged in this manner. The two dynamos are driven off the same engine, and the motors are coupled by belts to a common shaft, but each pair of machines are connected by a separate cable.

The *shunt-winding* is adapted for giving a fairly constant difference of potential or electro-motive force with a varying current.* It is consequently suitable for a dynamo which has to supply a number of motors running independently of each other, with or without varying loads. If the motors are to run at fairly constant speed with varying loads on such a circuit, they must also be wound in shunt. If they are required to work with a constant torque, say, pump-driving, a series-winding may be used with advantage. The "Andrew's House" installation is arranged in this way. The dynamo is shunt-wound and the motors are series-wound. It is practically impossible with the shunt system to maintain a constant difference of potential at any given point—a matter oftentimes of no little importance. Every variation of load means a difference in the quantity of current flowing in the main cables; and although the dynamo may maintain practically the same electro-motive force at its terminals, yet, since the number of volts lost in the cable is proportional to the current, the tension at any given point must vary directly as the current difference. And since the speed of a series-motor running with a constant torque is directly proportional to the electro-motive force of supply, this variation of tension means a corresponding difference in the motor speeds. If a shunt-motor be used the speed will not vary so fast as the electro-motive force, but yet the speed is roughly proportional to the tension. Thus, supposing we have a shunt-dynamo on the pit-top giving 250 volts at its terminals and supplying motors at various parts of a mine with, say, a maximum current of 100 ampères, distributed according to the work as in Fig. 11, and let the cable resistance to the first distributing centre be ·25 of an ohm, then the number of volts lost under these conditions up to this point will be $= C R = 100 \times \cdot 25 = 25 \cdot 0$. The speed of the motors neglecting further loss in sub-mains (and other disturbing influences) will be proportional to $250 - 25 = 225$ volts. Now assume that one-half the work be taken off, and the current required be only 50 ampères, the tension at the distributing box will be now—

$$\begin{aligned} E - C R &= 250 - 50 \times \cdot 25 \\ &= 250 - 12 \cdot 5 \\ &= 237 \cdot 5 \text{ volts,} \end{aligned}$$

and the speed of the motors will be roughly proportional to this figure, viz., 237·5, or, the speed will be increased in the ratio of

$$\frac{237 \cdot 5}{225} \text{ or 5 per cent. approximate.}$$

This is not a very serious alteration of speed, but in practice the motors at the extremities of the system would be affected to, say, 15 per cent., or even 20 per cent., through other losses.

This shunt-winding is not adapted for motors which have to start against a very heavy load, since the torque they can exert, when run off a series-dynamo, is a minimum when they are at rest. You will remember the series-winding under the same conditions gives a maximum torque. If a shunt-motor be driven by a shunt-dynamo the torque at starting is theoretically a maximum, *i.e.*, assuming the value of the electro-motive force of supply is maintained. Practically, the tension always falls when the circuit is closed, and it may be so much as to prevent the motor from starting on full load (*see* Fig. 5).

The ideal method of winding the dynamos for a general system of distributing power is a combination of the series and shunt methods. It is called *compound-winding*.

* In practice, the terminal electro-motive force will vary about 10 per cent. to 15 per cent. at least between no load and full output.

In this arrangement a series-coil is wound on the magnets and coupled in series with the armature, so that the whole of the current generated by the armature flows through it. A shunt-coil is also wound around the magnets, and its ends are coupled to the ends of the armature and series-coil circuit (sometimes called the main circuit). (*See* Fig. 3.)

If it be desired to arrange the dynamo to give a constant terminal difference of potential with a varying current, this shunt-coil will have the same current always flowing through it, and will contribute a constant magnetic field. The series-coil, on the contrary, will have a current flowing through it in direct proportion to the external current, and hence will give a quantity of magnetism directly proportionate to the current required. This is the system of compounding for a constant difference of potential expressed in its simplest form. The chief

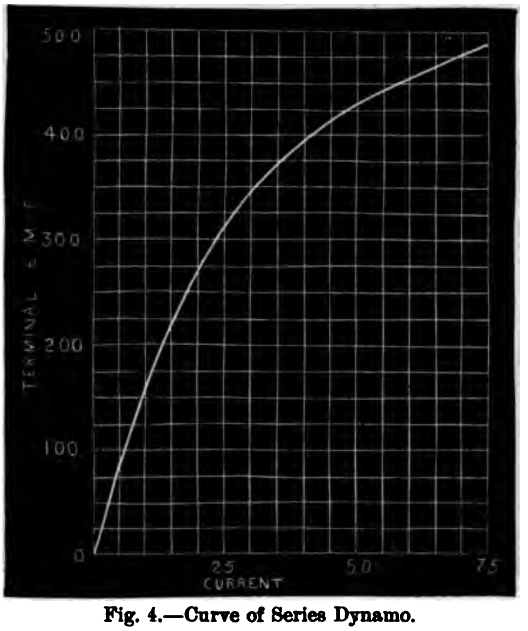


Fig. 4.—Curve of Series Dynamo.

advantage of this winding over the pure shunt is that the ratio of series and shunt effects can be arranged to give an approximate constant difference of potential at a point distant from the dynamo terminals, such as the distributing box in Fig. 11. A dynamo thus wound is said to be over-compounded (*see* Fig. 6).

An approximation to this regulation can be made by using large shunt-dynamos and very heavy copper mains; but, probably, for most cases of mining work, the compound-winding will be preferred, since smaller mains can be used.

Characteristic Curves of Dynamos.

The writer thinks that an explanation of the "characteristic curves" of the different types of machines referred to will be only a logical conclusion to the preceding general statements, since without some knowledge of the properties of dynamos and motors a proper appreciation of the capabilities of electrical machinery is impossible.

The "characteristic curves" of dynamos are curves showing the variation of electro-motive force with reference to the current. They stand to dynamo-electric

machinery in the same relation that indicator diagrams do to steam engines. The performance of a dynamo can be gauged by their means, in a similar manner to the work of an engine by the shape of the "card." But there is a difference between the two. The dynamo really has two "characteristics"—one the internal or true characteristic, connecting the total electro-motive force of the armature with the current flowing in the field-magnet coils; and the other the external characteristic which shows the variation of the terminal electro-motive force with reference to the external current. This latter is the more important curve for the user of electrical plant; the former is chiefly of use to the machine builder. The

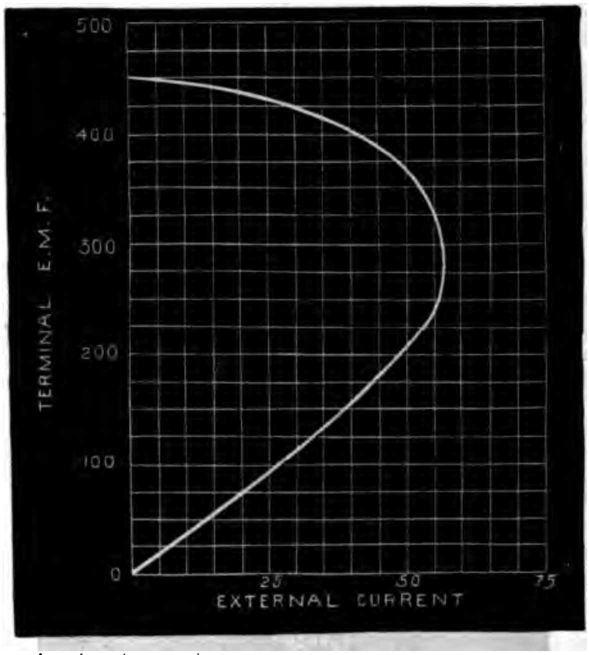


Fig. 5.—Curve of Shunt-Dynamo.

limits of the present subject will only admit of an examination of the external characteristics. The method of taking the external characteristic of any machine is simple. The machine is run as a dynamo at a suitable speed of n revolutions per minute. Observations of terminal electro-motive force and main current are simultaneously made, and plotted to any scale, the volts as ordinates, the ampères as abscissæ. The value of the current is varied from zero to the required maximum by adjusting the external resistance. The internal characteristic is calculated from the curve thus obtained, and the known value of the internal resistance of the machine.

Fig. 4, Curve 1, is the characteristic curve of a series-wound dynamo calculated for a constant speed of n revolutions per minute.

It is apparent that each value of current in the abscissæ corresponds to a particular number of volts. The electrical output of the dynamo for any current is given by multiplying the number of ampères by the corresponding number of volts. The result thus obtained is expressed in watts: dividing this quantity by 746 the output is given in horse-power.

On inspecting the curve it is apparent that the output of the dynamo is strictly proportional to the work required. There is no waste of energy when running light. Assume a load on the motor requiring 20 ampères, the number of volts corresponding is 275, or an output of 5,500 watts = 7·4 horse-power nearly. Now let the torque increase to 50 ampères, the volts will be 425, the watts 21,250, and the horse-power 28·5. If the load be *nil*—that is, if the circuit be opened—the ampères and volts are *nil*, and consequently the output is also *nil*. This is a most important feature in electrical transmission, and is one of the reasons why the coal consumption is always small with a well-designed plant.

The series type of dynamo is only used to drive one motor, also series-wound.

Fig. 5 is the external characteristic of a shunt-wound dynamo, running at constant speed.

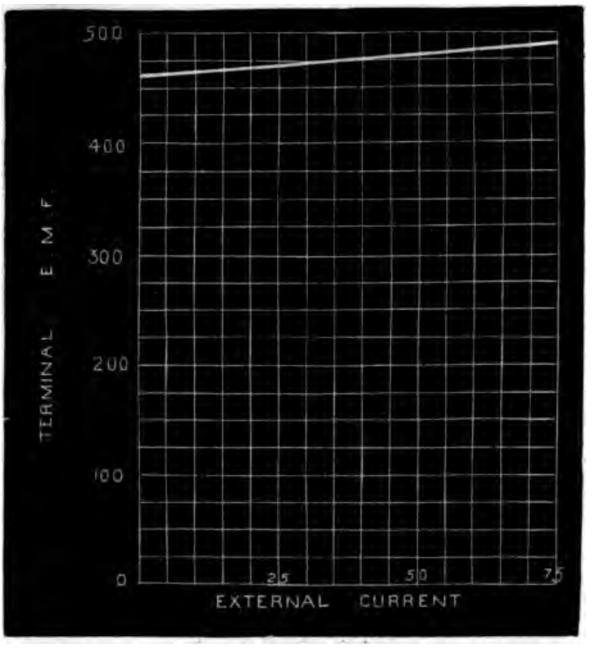


Fig. 6.—Curve of Over-Compounded Compound-Dynamo.

The chief point to note is the large possible variation of current for a relatively small difference in the value of the terminal electro-motive force. Hence, a number of motors could be run off such a dynamo, and have their loads varied within wide limits, without largely affecting the speed of each other. It will be noticed that if the load be raised so that the work corresponds to that part of the curve which is vertical, the electro-motive force rapidly falls, and if the load be maintained there is risk of the current falling away to zero. This would obtain in practice if the motors were to be overloaded. This explains why a shunt-dynamo is not suited for running motors which have to start against heavy loads. (Special arrangements can be made to modify this peculiarity in some degree, such as first exciting the field and then closing the armature circuit through a resistance.)

Fig. 6 is the external characteristic of a compound-wound dynamo, and is obtained by a combination of the series and shunt-windings.

In this the electro-motive force is practically constant throughout the limits of the designed current variation, or it can be arranged to any desired slope. This is the type of dynamo which, in a properly modified form, the writer believes will be used for supplying power over mines in the immediate future.

MECHANICAL CHARACTERISTICS OF MOTORS.

Motors have also their characteristics, but they are of less importance to the present subject, and they also require a better acquaintance with motor work than is assumed here. Reference, however, will be made to what are called "mechanical characteristics," *i.e.*, curves showing the variation of speed for different values of torque or work per revolution.

Fig. 7 shows this relationship in a series-wound motor, supplied with current at constant electro-motive force.

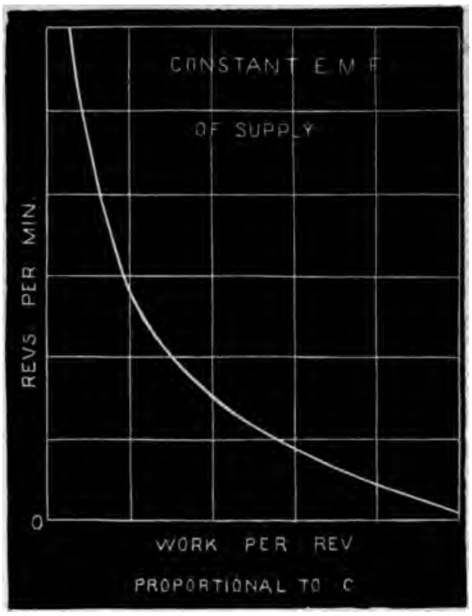


Fig. 7.—Series-Motor.

Note that the work per revolution is a maximum for a minimum speed, *i.e.*, at starting.

Fig. 8 gives the result with a shunt-wound motor.

Note that the work per revolution varies largely for relatively small differences of speed. If the load were pushed beyond the limiting value of current shown in the diagram, the curve would rapidly drop; but, assuming the potential difference to be maintained at the terminals, the motor would not stop till the current in the armature circuit were equal to the terminal volts divided by the armature resistance. The torque then would not be so great as that possible with a series-winding, since the field excitation would be approximately constant through the range of the curve. (Practically, it is not possible to maintain the motor terminal electro-motive force constant owing to the fall of potential in the leads, and thus the field is proportionately decreased as the load is increased.) In the series-motor both field and armature are temporarily strengthened at starting.

Fig. 9 gives the same with a compound-wound motor.

Note there are two ways of coupling up the two field windings. In Curve 1 the windings are differential, *i.e.*, the series-coils magnetise the field in the opposite

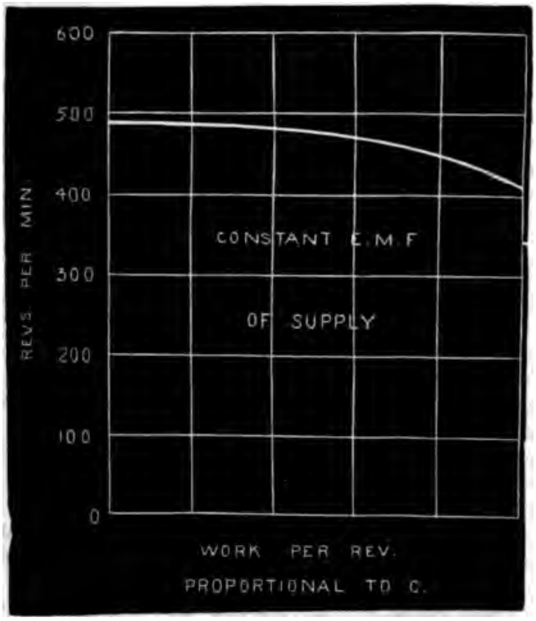


Fig. 8.—Shunt-Motor.

sense to the shunt. This arrangement gives a nearly constant speed throughout the limits of the design. If the machine be overloaded, the series-coil is likely to

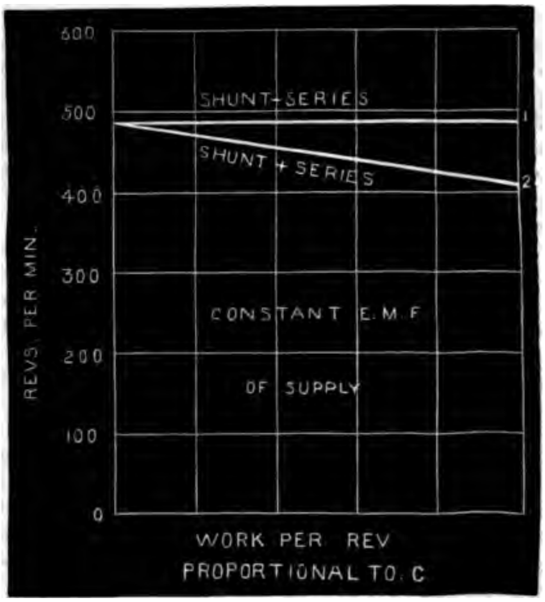


Fig. 9.—Compound-Motor.

neutralise the shunt effect, and the motor will stop, and may even reverse. This type of motor is thus not adapted for starting against heavy loads, but may be used where regularity of speed is of paramount importance.

Sometimes the coils are wound so as to add their effects. The result is shown in Curve 2. This winding does not give such a constant speed as the pure shunt-winding, but since the series-coil is cumulative and not differential the motor will start against a fairly heavy load, and will maintain a speed sufficiently uniform for most purposes between the limits of the design. Some care is required in starting motors of these types.

In these last three diagrams the abscissæ are proportional to either the current, the torque, or the work per revolution, for these quantities vary together.

Comparing the curves in Figs. 7, 8, and 9 it is evident that with a variable load the shunt and compound-windings are alone admissible, if a fairly good regulation of speed be desired. The series-motor when supplied at constant electro-motive force is only adapted for a constant load—say a pump or a fan—but is, *par excellence*, the machine for starting very heavy loads, as in hauling plants, with main and tail, or single ropes.

This reference to the characteristic curves of dynamos and motors is very brief, but a closer description would be unsuited to the present occasion.

The mining engineer of the future will require to know as much as this, and probably more—but *quantum sufficit*.

The writer has dipped thus far into the technics of electrical machinery in order to show that the question of the distribution of power by electricity over large areas in mines has been already studied, and presents no insurmountable obstacles to those responsible for the erection of such plants.

It will now be convenient to examine a little more in detail the three methods of distributing energy by direct currents, and to summarise the properties of each.

I.—Series-Wound Dynamo and Motor.

Mention has already been made that this arrangement is only suitable for a pair of machines, that the motor exerts a maximum torque at starting, and maintains a nearly constant speed between the limits of the designed load if the dynamo speed be kept uniform. It is necessary to refer again to the last-mentioned peculiarity of this system, viz., the constant speed. In Fig. 10, Curve 1, shows the variation of electro-motive force with the current in a series-dynamo running at constant speed; Curve 2 shows the same relationship between the electro-motive force and current in a series-motor designed to be run by a series-dynamo; Curve 3 shows geometrically the summation of the electric resistance of the dynamo, motor, and cables. Now, Curves 1 and 2 have been so designed that the difference between any two corresponding ordinates is equal to the numerical value of the same ordinate in Curve 3. Also the current in both machines will always be the same, for they form one continuous circuit, and Curves 1 and 2 were both plotted at constant speeds. Since the difference between them is equal to the electro-motive force necessary to overcome the resistance of the entire circuit, it follows, if the dynamo be run at a constant speed, the motor must also run at a constant speed. There will thus be a nearly perfect regulation of the output of energy to meet the demands of the motor, and this energy will be supplied in such a manner as to keep the speed fairly constant. In practice it is not possible to obtain an absolutely constant motor speed; but the regulation can be made sufficiently near for any ordinary purposes. This system is not adapted for electric lighting, either with the lamps in parallel or in series, but a few lamps may be run with suitable precautions.

Curve 1 is the internal characteristic of a series-dynamo running at a constant speed of *n* revolutions per minute. Curve 2 is the internal characteristic of a series-motor designed to be driven by the dynamo. Curve 3 represents geometrically the summation of the resistances of dynamo, motor, and cables. Note that with series-machines the field is the same as the external current.

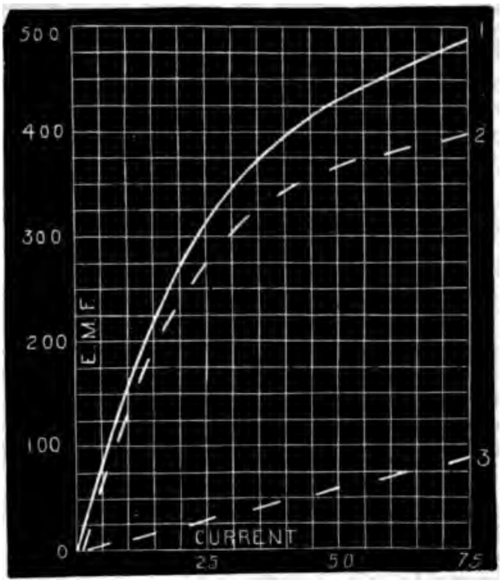


Fig. 10.

II.—Constant Current Transmission.

In this case, since the value of the current remains the same, variations of power can only be made by directly proportional variations of electro-motive force. The system is applicable to any number of dynamos and motors running in series with each other, and is theoretically only limited by the safe working limits of the tension.

Since high tensions (several thousand volts) are not likely to be used in mines, there will be no object in discussing this system at length. Briefly, the advantages are a capacity for transmitting energy over very extended areas, where the power is used at widely distant points, with a moderate expenditure of copper in the cables. The chief objection, other than the high tension, is the necessity for a governor of some form to each motor, and probably to the dynamo or dynamos also.

This system, however, is useful in particular cases. The writer has recently designed for Messrs. Immisch & Co. two motors to run on a constant current circuit of ten ampères and about 2,000 volts. Each motor will develop about 10 B.H.P. at a speed of 800 revolutions per minute, and will absorb about 1,000 volts. These machines will each run a set of three throw pumps, with 3 inch rams of 9 inch stroke. Each pump will raise water against a vertical head of about 750 feet, making a total lift of 1,500 feet, with a 4 inch rising main about 1,800 feet long. The dynamo is an arc lamp machine, and will be used for lighting at night and running the motors by day. These motors are fitted with high-speed centrifugal governors which vary the value of a shunt coupled to the field terminals.

The speed of the motors for a given torque is adjusted by a spring on the governor. Since the load on the pumps is practically constant, the governing device will only be used in case of accidents, such as a clack getting off its seat, or a failure of the suction. If, however, the load were to be frequently varied, the governors would keep the speed between the arranged limits. There is not much demand for constant-current motors at present, nor does the writer think they are likely to come into general use. They are chiefly adapted to arc lamp circuits, in which they run either in series with some of the lamps, or they are only run by day when lighting is not required. They may also occasionally be chosen to transmit power over very widely distant centres. The constant current system is only suitable for lighting by lamps run in series, or in multiple series, in the main circuit.

III.—Constant Potential System of Transmission.

The features which make this system the most suitable for general distribution in mines have already been brought out when discussing the characteristics and mechanical curves of dynamos and motors. The pure shunt and the compound dynamo have also been compared, and the general advantage of the latter shown. Before referring to a practical illustration of this system, the writer will restate the practical properties of the constant potential system with compound-dynamos.

1. The dynamo, or dynamos, can be arranged to maintain a constant difference of potential at any desired centre, so as to distribute energy from this centre at the same pressure, no matter how the load may vary within the limit of design.

2. Either series, shunt, or compound-motors may be used on such a circuit, so as to meet the different requirements of work.

3. A suitable unit size of dynamo being chosen to start with, the plant can at any time be increased by the addition of one or more dynamos. All of these dynamos can be coupled to the omnibus mains, and will deliver electricity in proportion to the required output; just as two or more engines can be coupled to the same shaft, or several compressors can be used to charge a common receiver and service pipe.

4. Various sizes of motors can be run on this circuit if they are wound for the same electro-motive force. Thus a 50 horse-power motor can be used for hauling or pumping, a 2 horse-power motor for rock drilling, and a 10 horse-power motor for coal-cutting.

5. Power can be rapidly taken to any part of the pit by running temporary cables from the nearest distributing centre, and any of the motors can be connected. This facility for rapid work in the case of breakdowns, temporary feeders, and perhaps, with certain precautions, sudden outbreaks of gas, will be of marked importance in the near future. Indeed, the electrical distribution of energy by the parallel system has all the flexibility of compressed air, steam, or water systems, with the further advantage of cheapness, high efficiency, and freedom from bad breakdowns.

6. In case of accident to any part of the system, the damaged cables or machines can be easily disconnected from the mains without affecting the rest of the plant.

7. Incandescent or arc lamps can be run off the mains at any part of the circuit (lamps being placed in series to take up the E.M.F.). The parallel system meets equally well the requirements of light or power. The importance of this will be generally admitted.

The chief drawback to the parallel system is the cost of the copper mains, if a relative low tension of supply be selected so as to run small as well as large motors. The writer proposes the following scheme to meet this difficulty in distributing energy in mines:—

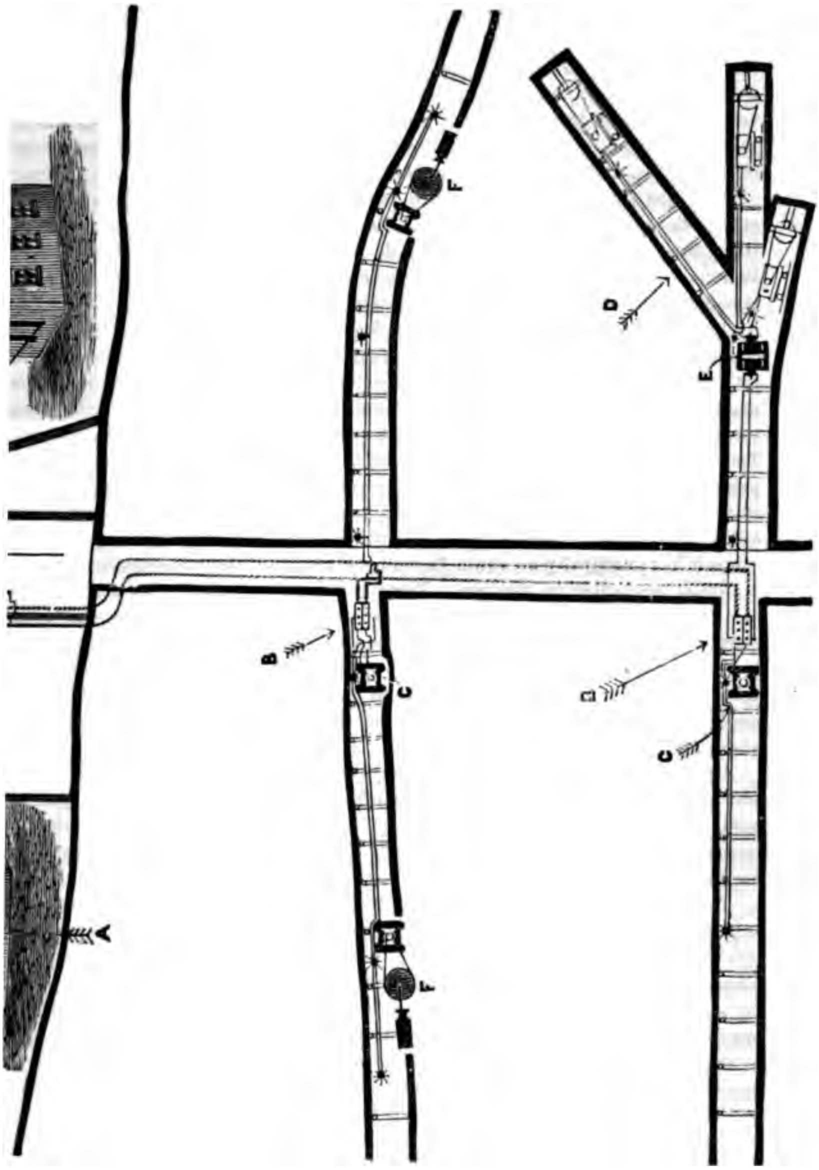


Fig. 11.

Rough diagram showing a general application of electrical power to mining operations on the direct-current parallel system, with transformers.

A is the dynamo-house; B, B, distributing centres; C, C, hauling motors; F, F, pumping motors; E, direct-current transformer; D, rock-drills and coal-cutters. An arc lamp is shown on the pit-top, and the stars indicate incandescent lamps at various points in the roads and workings.

Fig. 11 is a rough diagram indicating the way in which such a general system would be applied. The details, with the exception of the cables, are sufficiently clear. Since the size of the copper for a given transmission of energy depends principally on the amount of current, the tension selected will be usually as high as possible. But there is a limit to the voltage, depending on the extent of the work area, the difference between the sizes of the motors, the insulation resistance of the system, and the general character of the roads, etc.

Hitherto the writer has not used more than 725 volts below ground, and then only with separate pairs of machines. In America much higher tensions are sometimes used, but the same restrictions do not apply to the two countries. In Great Britain, with the conditions obtaining, both legal and natural, it is not likely that tensions of more than 500 volts will be used for an extended system of distribution. And even this tension will be too high for serving the motors running rock-drills, coal-cutters, dip pumps, and auxiliary fans. Indeed all the larger motors near the pit bottom will be run at the higher voltage, and the smaller and more distant machines by a lower electro-motive force. This lower tension will be obtained through transformers, or direct current converters, as they are sometimes called. These will transform a small current at high pressure to a large current at low pressure. The transformer somewhat resembles a motor with two armatures. It is really a combination of a motor and dynamo. It requires no attention beyond oiling the bearings, keeping clean the commutator, etc., and adjusting the brushes. Since it has practically no strain beyond the torque of the two armatures, the wear is almost negligible in practice. These transformers could be locked up in cabins on the main intakes. They could be inspected at regular intervals, and could be started or stopped at distributing boxes arranged at suitable spots. Transformers have not yet been used below ground to the writer's knowledge. Their utility, however, is so apparent that he expects to find them in demand before long. Their merit has already been appreciated in more than one general scheme for distribution above ground.

By the proposed scheme an economy of copper could be secured in the mains, and the cost of the smaller motors would be lessened. For high tension small motors are not only expensive to wind, but also uncertain as regards insulation. The cost of the sub-mains would be practically the same in any system, because it would not be practicable to use very small or very weakly insulated leads.

The use of an uninsulated *return* is very tempting, since there is plenty of old cable lying about most collieries. The writer has in several cases used iron rope for this purpose with success. But it must be recollected that the risk of possible complications by short circuits would be increased by every additional motor. Considering all things, he does not advise the use of naked returns in cases where more than one or two motors are run off the same dynamo, particularly if the tension be high or the power large. With the system here proposed there would be little objection in most cases to using a naked return on the low tension circuits, *i.e.*, for the returns to the transformers, assuming the high tension mains and the dynamos and motors supplied directly from these mains were properly insulated. It is necessary to note that the cost of the transformers and their erection have to be charged against the system. This extra cost will be about £8 per horse-power per transformer. It has to be compared with the saving effected in the copper of the mains, and to the decreased cost of small motors. These two points should alone be sufficient to warrant the arrangement, without reference to the increased flexibility, and the safe use of both large and small motors. It has been proposed to drive low tension dynamos off the shafts of large pumping motors, and utilise the current to run small motors for rock-drills, etc. Messrs. Immisch & Co. have already made such an

arrangement for a Bohemian tin mine. This method is, however, not always applicable, and generally will not be so handy as a transformer system.

Transformers can also be used on constant current circuits. With such a method of distributing energy the high tension main current would probably not be used directly to drive motors in most cases, but would be converted into a lower potential current by transformers. These transformers would be placed in suitable centres for distributing power to the motors. The writer did not refer to this under the head of "Constant Current Transmission," because he believes the high tension current necessary in the primary circuit to be unsuited to ordinary mining practice. There are some cases where, perhaps, this system would be advantageous, but the constant potential distribution is more likely to be adopted in the immediate future.

This paper would be incomplete without reference to the second branch of electrical distribution of power referred to under the head of "Alternate Currents." Alternate current dynamos have been used with great success, but there are several practical difficulties in the construction of efficient self-starting non-synchronous motors, *i.e.*, motors which are both capable of starting against a large torque without extraneous help, and which also can run at speeds bearing no simple ratio to the speeds of the dynamo. Nine years ago it was demonstrated that if two alternate current dynamos were coupled in series with each other, and both their fields were excited by an independent direct current dynamo, that if one machine were driven the other would run as a motor, and would do work in an efficient manner; but the speed of the motor had to synchronise with that of the dynamo, or it would stop, and it could not be started again without first slowing the dynamo and starting the motor by some independent means. Then as soon as the two machines got into step, as it is technically called, the motor would exactly follow all the variation of the dynamo rate of rotation.

Such a system of transmission, although possessing a remarkable power of self-regulation, and a high efficiency of conversion, is only adapted to a pair of machines with separate exciters, and necessitates some device for starting the motor (such as accumulators). It may pay in cases of transmission of energy from distant water-power, but is not applicable to mining work in general at present.

Rapid strides are being made in this branch of electrical engineering, and it is not safe to predict anything. At present we have a few self-starting alternating motors, some made synchronous after a certain speed is reached, and others always non-synchronous. All of these, however, seem to be rather experimental. The writer does not know of one giving an efficiency of more than 50 per cent. to 60 per cent. at the best. This type of motor is capable of parallel running, of almost perfect speed regulation, and, moreover, in some forms has no brushes, so that there is no sparking.

Alternating current distribution systems will certainly involve transformers. These, however, contain no moving parts, and are so far preferable to the direct current transformers. There are advantages and also disadvantages attending the use of alternate currents, but it would be inconvenient to discuss them here. This brief allusion must be sufficient for the present.*

In all that has been written in this paper the writer wishes it to be distinctly understood that the danger likely to result from the use of an unprotected motor in an explosive atmosphere is not glossed over.

In metalliferous mines and those coal seams which are free from gas there can, of course, be no need of any particular care in selecting the site of electrical machinery. In most collieries the "intakes" are safe enough, although the

* It is open to doubt whether an alternating parallel system of distribution can possibly be so efficient as a direct current system. Certainly, judging from our present standpoint, the plant efficiency of the alternating system will be much less, and consequently the prime cost will be more.

"returns" and "faces" may be dangerous. In most of such pits there would probably be little, if any, risk with fixed motors for haulage, pumping, etc., on the main "intakes." For, assuming a sudden outbreak of gas, before the main air-way could be fouled the motors could be stopped, and having once opened the switches all danger from this source would be at an end.

There are pits in many parts of the country where naked lights are used in some of the roads and workings, and protected lamps in others. In these, wherever naked lights are used, electrical plant can be employed with equal safety.

Speaking generally, wherever naked lights are used electricity is not dangerous; and in pits subject to occasional outbursts of gas it can be safely used, with due caution and proper ventilation of the motor house.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT MASON COLLEGE, BIRMINGHAM, DECEMBER 5TH, 1889.

MR. HENRY LEA IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

A paper upon "Safety-Lamps," by Mr. H. W. Hughes, had been announced for this meeting, but Mr. Hughes stated, with regret, that he had been unable to finish the paper. He had been very busy, and, in addition, the inventor of one safety-lamp had been modifying his lamp and had not yet completed it. The paper would be read at a subsequent meeting.

The SECRETARY announced that the first General Meeting of the Federated Institution was fixed for the 22nd and 23rd of January, at Sheffield.

A discussion then took place with regard to the admission of Associates into the Institute.

The SECRETARY said that at the last Council meeting a resolution was passed, that arrangements should be made for a class of Associates in connection with the Institute, and it would be quite competent for this meeting to go into the question, which could be confirmed at the annual meeting. He suggested that they should have a similar rule to that adopted by the Chesterfield Institute, and, he believed, by the North of England Institute also.

Mr. SOPWITH—The arrangement in the North of England Institute is that they are Associates.

The SECRETARY—They are taking into the Federation even that class of members.

Mr. H. W. HUGHES said that Associates had all the privileges of Ordinary Members except the right of voting.

The SECRETARY gave particulars of the subscriptions at the Chesterfield Institute. He thought the North of England Institute had adopted the £1 1s. subscription.

Mr. SOPWITH—The alteration has been made in the North only.

The SECRETARY—Previously, their Associate Members were simply mining and mechanical engineers who were not considered of sufficient position or eminence to come in as Ordinary Members—something like the Institution of Civil Engineers' arrangement.

Mr. H. W. HUGHES said the Council would have power to reject persons not in every way eligible.

Mr. SOPWITH said they wanted somebody to swell the numbers.

The CHAIRMAN—The rules to which this relates are Nos. 2, 3, and 5. It would be interesting to know how far the class of Students has developed since these rules were passed.

The SECRETARY—It has been a retrograde movement. We had six at first, and now we have one.

The CHAIRMAN—It would not be satisfactory to introduce a class of Associate Members and then to find that no one joined.

The SECRETARY—No; but there is a large number of people holding second class certificates.

Mr. H. W. HUGHES thought second class certificates were scarce.

The CHAIRMAN said it seemed an important point whether Associates would come if they were provided for. With regard to the subscription, he said the ordinary subscription was £1 1s. with an entrance fee of £1 1s., and the subscription of Students was 10s. 6d. with an entrance fee of 10s. 6d. He thought an Associate's subscription should be between the two.

The SECRETARY—In the Chesterfield Institute they have an entrance fee for their Members and another class which they call Subscribing Members, but no entrance fee for the Associates or Students.

Mr. H. W. HUGHES—I take it that the ultimate position of a Student is a Member.

The SECRETARY—Decidedly; a lot of our Students have come into our Institute. The second-class men, unless they get first-class certificates, would not be likely to come in.

Mr. H. W. HUGHES did not think the Institute would get a large influx of members.

Mr. SOPWITH—I do not think there is any harm in introducing the thing and seeing how it goes.

The CHAIRMAN asked whether Associates could conveniently attend meetings at the usual time at which they were held.

Mr. SOPWITH said the members ought to make an effort to improve the meetings. Now, that they were joining the Federation, and as that Institution would ultimately come into this district, they ought to be prepared to meet it in a proper way.

Mr. H. W. HUGHES—We have made a very bad show already in regard to the Federated Institution. Members do not seem to understand all the advantages.

Mr. HAYWARD—Would it not be well to print a circular and send it to the members, setting forth the advantages of membership of the Federated Institution?

The SECRETARY—Several have been sent, setting forth the advantages most fully.

The CHAIRMAN said the subject before the meeting was the admission of Associates. He thought, however, that that meeting was not large enough to be considered a representative one.

Mr. H. W. HUGHES—I think we are all of the opinion that if we can get these people to join it would be desirable. Perhaps we should pass a resolution to the effect that they be admitted, and leave the details to the Committee.

The SECRETARY said it would be better perhaps to delay it till the Rules Committee had reported.

Mr. SOPWITH said, as this question was not included in the agenda for the meeting, nothing formal could be done. It would come within the meaning of the revision of rules, and could therefore be dealt with by the Committee appointed for that purpose.

The discussion then dropped.

In accordance with Rule 9 Mr. D. Peacock and Mr. John Hughes were appointed scrutineers.

Mr. D. Rogers and Mr. W. H. Whitehouse were appointed to act as Auditors.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL MEETING,

HELD IN THE EXAMINATION HALL, MASON COLLEGE, BIRMINGHAM, ON MONDAY, MARCH 3RD, 1890.

MR. HENRY LEA IN THE CHAIR.

The minutes were read and confirmed.

The SECRETARY, Mr. Alexander Smith, read letters of apology for inability to attend the meeting from Dr. Poynting and Dr. Lapworth.

The SECRETARY also read a letter from Mr. Rudler, enclosing a communication from the Lords of the Committee of Privy Council on Education acknowledging the receipt of a set of the Transactions of the Institute.

The report of the scrutineers of the voting for a President and officers for the year having been announced to the meeting, the Secretary read the report of the Council for the past year, together with the Auditor's report and balance sheet.

SCRUTINEERS' REPORT FOR 1890.

President—Henry Lea; Vice-President—John Williamson; Treasurer—W. J. Hayward; Secretary—Alexander Smith; New Members of Council—W. H. Glennie, J. H. Cooksey, W. Wardle, E. B. Marten, and W. J. Davies.

(Signed) DAVID PEACOCK, JOHN HUGHES, } *Scrutineers.*

February 27th, 1890.

REPORT OF COUNCIL FOR 1889.

GENTLEMEN,

The Council have pleasure in congratulating you upon the decided improvement in the important industries with which you are so intimately connected, an improvement which should ultimately have a beneficial effect upon the Institute.

There have been nine General and six Council meetings held throughout the year.

You have elected eight new members, and five have resigned, so that there are 122 now on the list, as against 119 last year.

The receipts have been £112 14s. 3d. and the expenditure £100 10s. 8d., consequently there is a balance in cash to credit £12 3s. 7d., by which amount the bank balance has been increased, and stands at £279 11s. 4d.

It is satisfactory that you have again avoided trenching upon the reserve, and have increased it instead. With the amount of subscriptions due, the total assets amount to £339 18s. 10d., without taking into consideration the value of the books, models, book-case, etc., at Mason College.

Some excellent papers have been read, viz.:—"The Transmission of Power by Electricity," by Mr. Frederick Brown; "The Electrical Units of Measurement," by the Vice-President, Mr. Henry Lea; "The Application of Electricity to Mining," by Mr. H. W. Hughes; and "Notes on Mining in North Mexico," by Mr. W. H. Glennie.

The discussions and papers upon that very vital subject electricity, which were principally evoked by Mr. Sopwith's paper, read at the end of 1888, have been particularly interesting and instructive, and Mr. Glennie's entertaining paper on Mexican mining is also deserving of special note.

Several meetings were taken up in discussing, in detail, the scheme formulated by the Joint Committee for the federation of the several Mining Institutes, and you suggested some minor alterations, which were submitted by the Secretary to the above Committee at their meeting in London in July last, when they strongly urged that you would forego them till the consideration of the formation of Bye-laws by the Council, and accept the scheme in its present form as the other Institutes had done. In compliance with this request you passed the following resolution at the August meeting:—

"That the Secretary be hereby instructed to send out circulars inviting members to join and subscribe to the Federated Institution of Mining Engineers as at present formed."

The circulars were duly sent, and as a result forty have joined and paid their extra fees to the Federation, and the Institute will have to pay 10s. 6d. for each of the members who have not joined in accordance with the scheme. It is considered rather remarkable and certainly disappointing that so few comparatively have availed themselves of the particular advantages of this Federation, especially as the whole of the members in the other Institutes, to the number of 1,160, have federated. It was contemplated in the last report that the whole of the members would join in a body, as in the case of the other Institutes, and that the subscription would be raised to allow of it. The President and leading officials of the Federated Institution are emphatic in pressing that this should still be done, and your officers who have attended the meetings of the Federation are also of the same opinion, so that it is hoped steps will be taken to effect this within the next year. It is scarcely conceivable that any member would object to this course if he fully appreciated the advantages. The combined Transactions thus obtained are very valuable, and the meetings in the several districts will be exceptionally interesting and instructive, and not only will papers be read upon the newest geological facts, but upon all the latest methods and improvements in mining science, with opportunities generally of seeing the different appliances treated upon in practical operation.

Mr. Arthur Sopwith has been elected a Vice-President, and Mr. J. Hughes a Councillor of the Federated Institution.

Your thanks are again due to the Authorities of Mason College for the accommodation they have provided. It has been your pleasure to vote ten guineas to the funds of this important educational institution, which sum was duly forwarded, and has been suitably acknowledged.

The Council, in conclusion, hope that you will not relax but materially increase your individual efforts to advance the interests of the Institute, by securing new members, reading papers, and attending as regularly as possible at the meetings.

The PRESIDENT, in moving the adoption of the report, said, I do not think my remarks need be lengthy. The report speaks very plainly for itself. There is a satisfactory part of it, and an unsatisfactory part. The satisfactory part is in the beginning, where it appears that the number of members is slightly larger than it was last year, and the expenditure is less than the receipts by the amount of £12 3s. 7d., which, I believe, has not always been the case. The unsatisfactory part relates to the federation of the Institute. I cannot help looking upon that part as not at all satisfactory. An important point is raised in connection with the

Federation, which, if we are to judge by the comparatively small number of our members who have joined, has not met with the support it deserves. I cordially agree with the last paragraph of the report, which expresses a hope that the members will not relax their efforts in connection with the business of this Institute.

Mr. JOHN HUGHES seconded the adoption of the report. He hoped that those members who had not yet joined the Federation would do so during the coming year.

The report was agreed to.

Mr. Wm. Bayley Marshall and Mr. Harry Sladden were unanimously elected Members of the Institute, and Mr. H. T. Butcher and Mr. A. W. Grazebrook, Students.

Mr. E. B. MARTEN moved a vote of thanks to the Council and officers for their services during the past year. Whatever success had attended the Institute was to a great extent due to their attention and work. He thought still there was something for the Council to do in making the Federation scheme a little better known. If it were thoroughly understood there was probably hardly a member who would not join it.

Mr. GLENNIE seconded the motion, and it was carried unanimously.

Mr. CLARKE acknowledged the resolution.

The PRESIDENT then delivered his inaugural address.

PRESIDENT'S ADDRESS.

My year of office as Vice-President has expired, and looking back upon it I cannot but feel conscious of many shortcomings, and in how much better hands the interests of this Institute might easily have found themselves.

In one respect the Institute has been unusually unfortunate. You will anticipate me in what I am about to refer to, namely, the loss of our esteemed and valued President very early in the session.

Of his ability to occupy this chair and to promote the best interests of the Institute, there can be no doubt in the mind of anyone who knew him and saw him engaged in the conduct of our meetings.

His unworthy successor feels all the more, by contrast, his own unworthiness. Nevertheless, the fact remains that this day I am honoured by your confidence in placing me in the proud position of President of this Institution for the current year, and however unworthy I may be of the honour which you have conferred upon me, I shall endeavour to the best of my ability to respond to your confidence, and to discharge the responsibilities of the position with advantage to the Institution. The past year has clearly shown the desirability of having both a President and a Vice-President in active occupation of their positions, for there have been occasions when the permanent retirement of the one and the temporary absence of the other have resulted in meetings being left without either. On such occasions I can conscientiously say that nothing short of the impossibility of being in two places at the same time has kept me from attending the meetings in question. With the valuable support upon which I am sure I may rely from our newly elected and eminently practical Vice-President, and assured of the kindly consideration and co-operation of the members of Council, of our talented Secretary, and of the members generally, I trust that the interests of the Institution may be worthily maintained, though I confess that the prospect of my responsibilities is not unattended with feelings of trepidation; and, gentlemen, opportunities for active work will not be wanting. We have recently become associated with the leading kindred Institutions in this country, and under the title of the Federated Institution of Mining Engineers we shall now enjoy the reciprocal benefits of membership with three similar Institutions, namely, the North of England Institute of Mining and Mechanical Engineers, the Chesterfield and Midland Counties Institute of Engineers, and the Midland Institute of Mining, Civil, and Mechanical Engineers, whose energy of purpose in matters relating to this Federation was strikingly illustrated not long ago by the numbers in which they attended the Sheffield meeting, and the admirable style in which the meeting was arranged for and was received in the town of Sheffield. I think it is our plain duty to look well to our relations with this new and honourable association, and to consider whether we are joining hands to the extent which is demanded by our position and importance in this district. Our current number of members is 122, and of this number forty, or less than one-third, have come forward to join the ranks of the associated Institutions. It is, I think, for the members to determine in their own minds whether this number is totally inadequate and disproportionate, and unworthy of our local name and standing. I submit that a legitimate subject for consideration would be whether we should not even now resolve to join as a body the Federated Institution, and thus, while attaining the many advantages attending the Federa-

tion, avoid once and for all the unpleasant possibility of finding that in the event of the Federation honouring us with a visit only a small portion of our members are qualified to receive the Federation as members thereof. I commend this to your serious consideration.

My further remarks on this occasion will not be lengthy, for there is a valuable and interesting paper to be read, and other important duties for our attention later on.

But from my standpoint as a mechanical engineer not much engaged in mining pursuits, and looking, therefore, at this great mining district of yours from somewhat of an outside spectator's point of view, I may perhaps be permitted to occupy a short time in referring to what has always appeared to me to be one of the greatest undertakings in relation to mining operations which could be entertained by any mining district. I refer to the engineering operations of the Mines Drainage Commissioners. To many of you who are in one way or another intimately connected or acquainted with the undertaking these observations of mine may seem commonplace and perhaps uninteresting, but to some the subject may be welcome. There is good reason to fear that the magnitude of this great work has been lost sight of in the financial struggle by which it has unhappily been accompanied. Prior to the year 1872 the pumping of the water from the mines which are now drained by the Commissioners' engines was a work which was done for the most part by individual colliery owners or occupiers, and was done in whatever way seemed good in their own eyes, each way, no doubt, being at the time the method best known to the individual practising it. Those days were analagous to the times when each person requiring water sank his own well, or requiring drainage made his own cesspool. Such primitive methods eventually gave way to the beneficial establishment of public water companies and public systems of drainage. In like manner has the individual pumping engine in this district given place to the public system of mines drainage.

The engineering operations were divided into two parts, namely, the surface works and the underground works, the latter including the pumping engines.

The extent of district or the area dealt with as to surface works may be viewed as an oblong figure of irregular outline, having a length of about 12 miles from north to south, and an average width of about 6 miles from east to west, its area being about 72 square miles. It extends from the great Bentley fault on the north to within a short distance of the summit of the Clent Hills on the south. Beyond its northern boundary, and outside the range of the operations of the Commissioners, lies the Bentley district. The area dealt with as to underground works comprises the whole of the aforesaid surface works area, with the exception of the districts of Oldbury on the east and Kingswinford on the west. The surface works area is unequally divided into two parts by the high ground at the Rowley, Dudley, and Sedgley Hills, the two opposite faces of which slope north-east and south-west, the latter being drained by the River Stour, the former by the River Tame. Originally a large number of subsidiary watercourses collected the surface water and delivered it into these two rivers. As long as the mines were being gotten in isolated patches and before the surface became much broken the water question was of little importance, for the watercourses carried off the surface water in a natural manner, and where any water got below it was easily pumped out as the supply was a purely local one, and even where it was not pumped, as long as the pits were separated by ungotten mines, the mischief did not extend. As, however, the minerals began to be extensively worked, the surface became more and more broken up, watercourses no longer carried off surface water but discharged it into surface depressions or swags whence it descended through fissures and disused

shafts into the workings below; and as the workings became more extended the water began to flow from pit to pit, and those in the deep began to experience great difficulty in dealing with the water which came down upon them. The evil thus became a rapidly increasing one, and reached such a pitch that in 1872 it was estimated that there were in the whole area, exclusive of Bentley, 139 pumping engines at work raising 48 million gallons of water per 24 hours. This enormous volume of water may be pictured to the mind in a very practical manner, by recollecting that it would fill the Birmingham Town Hall brimful fourteen times in 24 hours.

Now, were the whole of the coal removed from the mines drainage area, together with all the superincumbent materials, there would be presented to the view a huge basin having a bottom of a very uneven character, but of which the general tendency would be to fall away deeper and deeper from north to south, so that whereas, for instance, at a short distance north of Bilston the thick coal crops out at the surface, at Halesowen, near the southern boundary of the mines drainage area, it lies at 1,000 feet below the surface or 600 feet below sea-level.

Naturally, the shallower measures were worked first. Hence it was that from the northern portion of the area came the greater part of the trouble of underground water supply.

In the present Tipton district particularly the removal of the 10 yard coal had worked great havoc with the surface, and the main difficulties of the engineers had been in this district.

In the year 1886 I had occasion to investigate the subject of a portion of the engine power then at work and proposed to be set to work for pumping purposes, and I was then greatly impressed with the magnitude of the undertaking from three principal points of view, namely, 1st, the surface work necessary to intercept a large proportion of the water which found its way downwards through leaky watercourses, swags, and canal arms; 2nd, the establishment of powerful and economical pumping engines at central positions judiciously selected; and 3rd, the driving of levels in various directions to tap the pounds of water which had accumulated.

As to the first point, namely, the surface works, the character of them is visible to anyone who has eyes and travels in the district. Watercourses which formerly were not distinguishable from the swags full of water through which they passed have been raised, widened, and made of uniform section proportionate to the watershed which they drain; swags have been pumped out; leaky canal arms have been cut off from the main canal or have been repaired, and generally, the surface water has been so far prevented from gaining access to the workings, that whereas in 1873 48 million gallons per day were pumped up from below, now the pumping of 17 million gallons a day brings up to the surface all the "come" of water, and is, besides, gradually reducing the level of the pounds throughout the district.

As to the second point, I devoted especial attention to the pumping machinery, and after taking diagrams from the Moat new compound Davy engine, both from the steam cylinders above ground and from the working barrels below, measuring the temperature and volume of the water from the hot well of the surface condenser, and taking measurements and particulars of all the pumping engines which the Moat engine would eventually supplant, I arrived at the conclusion that an admirable and sufficient plant was being provided for the intended purpose, and that it would do its work with economy. The Moat engine was then and still may be open to improvement in the matter of the arrangement of its air-pump, from which the low-pressure cylinder did not obtain the full benefit of a high degree of vacuum, but this I looked upon as a comparatively small detail readily open to amendment.

At the time of my visits the number of engines had been reduced from 139 to 62. Since that time the process of reduction in the number of engines has been going on, so that, as nearly as I can ascertain, at the present time the whole "come" of the district is now being lifted by seventeen engines. And mark the result, whereas by means of the old engines the cost of raising 25,000 gallons of water 100 feet high varied from 11d. up to some unknown figure which it would be hazardous to conjecture, the cost of doing the same work by means of the new engines stands at 3¼d. A few of the old engines are still at work, and by their cost of working testify most strongly to the soundness of judgment by which they have been for the most part replaced by their more modern competitors.

As regards the third point, namely, the underground levels, of their substantial character I can testify from actual observation. Naturally these levels must constitute the last part of the work to be carried out, for until the water has been got down to the desired depth the construction of the levels cannot be proceeded with. They appear to me to be at once a most essential and a most difficult part of the undertaking, and it is only by patiently persevering in their extension that the full benefit of the whole design can be realised.

It may be well to recollect that the mining district, although possibly capable of being drowned out by water flowing from pit to pit, *over*flowing, that is, from one pit to another, is not capable of being drained by simply drawing off the water from one or two isolated points. There is not sufficient freedom of communication from pit to pit at the low level required for deep and complete drainage. Even if there ever had been general communication through broken rock or otherwise it would inevitably become choked by mud or silt or by general consolidation, and would refuse a passage to water. As an approximately correct illustration of, say the present Tipton district, let me suggest the following:—Conceive a large, shallow tank having a number of buckets placed within it and resting upon its bottom. Let the tank and the buckets be assumed to be full of water. Fix a pump whose suction pipe shall reach to the bottom of the tank. Proceed to pump out the water. You may be able to empty the tank, but the individual buckets will remain full of water, and the only way to empty the buckets as they stand will be either to put a pump into each, which will be too expensive, or to approach each one from the level of the bottom of the tank and bore a hole into it to allow its contents to find their way to the pump.

I have no doubt that eventually the question of emptying the buckets will be satisfactorily solved, and that then the district will become completely unwatered and its valuable stores of minerals will become generally accessible.

To sum up briefly the present position, the surface works have reduced the volume of water to be pumped from 48 million gallons per day to 17 millions; the modern pumping engines have reduced the cost of pumping in the proportion of from 11d. and upwards to 3¼d.; and the underground levels have to a considerable extent brought the water of the district within reach of the economical pumping engines, and will, if fully carried out, bring down the remaining water in like manner.

To my mind this is a work worthy of the engineering profession, and I can only hope that the day is not far distant when the renewed prosperity of the South Staffordshire district will more than reward all concerned for the difficult and troublous times through which they have had to work their way.

A remark which I made with reference to the condenser in the Moat engine leads me to offer a few observations upon a kindred subject, namely, upon condensation as applied to winding engines, and to suggest the reason why considerable economy should result. The particular requirements of winding engines are, 1st

that they shall be considerably above their work, because they must be able to impart a rapid acceleration to the ropes and cages when starting them in motion, and 2nd, that the valve gear shall be of such a kind as to render the engines very easily handled. The latter requirement is antagonistic to the employment of expansive valve gears, the feature of which is that they shall cut off the steam early in the stroke, whereas easy handling implies a valve gear by which steam shall be admissible during nearly the whole stroke.

To go at once to the practical application, let us assume a pair of engines having 36 inch cylinders, 5 feet stroke, and let us take first the case of a non-condensing arrangement. With a boiler pressure of 45 lbs. above the atmosphere, or 60 lbs. absolute, that is, 60 lbs. above the zero line of perfect vacuum, with a mean effective pressure of say 30 lbs. per square inch throughout the stroke, and with a final pressure of 35 lbs. absolute at the moment of opening the exhaust valve, commonly called the moment of release, these engines would develop at a mean speed of 15 revolutions per minute 276 indicated horse-power and would discharge 4,900 cubic feet of steam per minute corrected to atmospheric pressure, or 177 cubic feet of steam per minute per indicated horse-power.

This we will take as the result when the engines are doing nearly their utmost during the process of accelerating the load, the speed being taken at the mean between 0 and full speed of 30 revolutions per minute, namely, at 15 revolutions per minute as aforesaid.

After full speed has been obtained we will assume that a mean effective pressure of 15 lbs. per square inch throughout the stroke will keep them going at the maximum speed of 30 revolutions per minute, and that we then get a final pressure of 20 lbs. per square inch absolute at the moment of release. The engines will now exert 276 indicated horse-power as before, although they are now running at twice the previous speed. They are, therefore, working at only one-half their capability. They expel about 5,600 cubic feet of steam per minute corrected to atmospheric pressure, or 202 cubic feet per indicated horse-power, being nearly 15 per cent. more steam per indicated horse-power than before. Here we see at once a loss of economy due to running large engines much below their power, that is, at a low mean pressure throughout the stroke. The reason for this loss of economy in non-condensing engines is that our pressure of release must necessarily be something above atmospheric pressure, and, therefore, we must of necessity expel from the cylinder at each stroke one cylinder full of steam somewhat above atmospheric pressure, for under no circumstance is it of any use to expand steam below atmospheric pressure in a non-condensing engine, otherwise the engine will be working against a partial vacuum with a corresponding loss of power and economy.

But if we now add a condenser to the engines we at once lower the minimum pressure of release in the cylinder from atmospheric pressure, that is, from 15 lbs. absolute pressure to say 4 lbs. absolute pressure, that being the degree of vacuum produced in the cylinder by the condenser; that is to say, all our pressures will stand 11 lbs. lower or nearer to zero than before, and we shall get the following results. In the first case during the acceleration of the load our pressure at release will be 35 — 11 = 24 lbs. absolute, instead of 35 lbs. absolute, and the engines will expel 3,360 cubic feet of steam per minute (corrected to atmospheric pressure), as against 4,900 cubic feet per minute when working non-condensing. This represents a saving of about 32 per cent.

In the second or full speed case we shall have a final pressure of steam at the moment of release of 20 — 11 = 9 lbs. absolute, instead of 20 lbs. absolute, and the volume of steam expelled will be 2,520 cubic feet per minute instead of 5,600, or a saving of over 55 per cent.

In actual practice we shall not realise so great a proportion of saving as this, because, taking the full speed example as a basis of comparison, when we are working into a condenser our cylinder temperature will vary from 225 degs., due to a mean pressure of 19 lbs. absolute, to 153 degs. at 4 lbs. absolute, as against non-condensing temperatures of 250 degs. and 212 degs. respectively, being a range of temperature greater by 34 degs. for the condensing engine than for the non-condensing engine, which will cause more extensive condensation at the entrance of the live steam. But after allowing for cylinder condensation and for the power required to work the air-pumps, we shall find a very large saving in favour of adding a condenser to our engines.

My object has been to call attention to the broad principle which underlies the saving obtained by the use of a condenser in cases where engines are worked at a mean power considerably below their maximum. The subject is worthy of closer attention than is practicable on the present occasion, for the saving in steam obtainable under its principles means not only a reduction in the coal bill, but a less extensive boiler plant, and less annual expense in wear and tear and depreciation.

At the conclusion of the President's address, Mr. MARTEN asked what was meant by joining the Federated Institute in a body?

The PRESIDENT—Joining in a body is something that stands in very sharp contrast to what we have already done. We have 122 members; the number who have responded to the invitation to become members of the Federation is forty. This is less than one-third of our body, and, I think, quite inadequate.

Mr. JOHN HUGHES—What does it involve?

The PRESIDENT—It involves the payment by this Institute of 10s. 6d. per annum for every one of those members who have not joined the Federation; whether they join it or not, we have to pay 10s. 6d. per annum to the Federation on their account. That is to cover the cost of printing our own Transactions, which, after federation, no longer remains in our hands. If a member joins the Federation he pays only 15s. per annum in addition to his ordinary subscription to this Institute, making £1 16s. a year in all. The idea is that this partial joining on our part should be avoided, and that for the future we should become members of the Federation—joining it in a body in the same manner as other Institutes have done, and that our subscription should be £1 11s. 6d. per annum. Of course, if that plan was adopted I suppose all the members would either have to pay the increased subscription of £1 11s. 6d. and be members of the Federation, or retire from our Institute.

The SECRETARY—The other Institutes raised their subscriptions where necessary, so as to enable members to join the Federation.

The PRESIDENT—The benefit of belonging to an association of this kind, and the reduction in cost which must result from printing the journal on a larger scale, instead of printing for ourselves, is undoubted.

In reply to Mr. Watkins, the PRESIDENT said he thought it inadvisable to go further into the discussion of the matter at this meeting.

The PRESIDENT said that in the unavoidable and most regrettable absence of Dr. Lapworth, who was to have read a paper, Mr. Wallis, representing Messrs. Davis & Son, of Derby, had kindly consented to give particulars of a few recent electrical appliances, several of which were exhibited at the meeting.

Mr. WALLIS first gave a description of mechanical telephones. He said—As you are all probably aware, the mechanical telephone transmitter consists of a diaphragm from which runs a cord in tension to a similar instrument. The modifications which have been introduced have tended to make the resonance produced by the voice sharper, but the instrument is not a good one except for short and straight lines. My firm have lately introduced in place of the mechanical telephone a magnetic telephone, of which a specimen is exhibited. No battery is required. The instrument consists of a small coil of wire with a diaphragm of leather and iron a short distance in front of it. When the diaphragm is spoken against it is caused to approach nearer or recede further from the coil. This sets up currents in the coil, which are conveyed along the wire to a similar instrument at the other end. There is a bell attached to it to call attention, and that is worked by a battery, but the instrument itself does not require a battery to work. It can be taken round any number of corners.

Mr. W. B. SCOTT—What is the battery power?

Mr. WALLIS—About two cells. The current is set up in the transmitter when you speak before it by the vibrations of the diaphragm.

Mr. WATKINS—Do you work it independently of existing patents?

Mr WALLIS—This is perfectly clear of existing patents. With reference to electric lighting and power plants in this country we have done a good deal more in the way of electric lighting than we have in the transmission of power. A lead mine in Derbyshire which we lit some three years ago has not had any repairs to any part of the installation since it first started, and it has been working continuously. Two pits which we lit for the Clay Cross Co. at Morton, in Derbyshire, have been working for some eight or nine months. They are lit on the surface and underground, and we are now putting down a pump to be worked underground by the same dynamo. The same dynamo is also to be used for the purpose of charging electric safety lamps, and for ringing the bells with an accumulator which we have specially designed for that to charge off that circuit, so that if the dynamo stops the signal will not be interrupted. We have another power installation in prospect in which about ten or twelve horse-power will be utilised at each of two pumps in levels. The levels are now being driven, and, when finished, each of the pumps will be 3½ miles from the top of the shaft, and we are guaranteeing that 70 per cent. of the brake power shall be put on to the pump shaft at 3½ miles distance. The advantages of electric motors I do not think are sufficiently recognised among mining engineers. A motor is the smallest machine for giving off mechanical work that exists. A one horse-power motor can be put into a silk hat, and a 20 or 30 horse-power motor would need very little excavation, and is so light that it can be easily fitted up over the road if necessary. With regard to temporary overloads in such work as hauling, a motor will work for a short time at something like two or three times its full power without injury. As to the transmission of power on the surface, a great many metal mines are going in for the system of suspension-transmission known as "telpherage," and I should think it would be applicable to collieries as well. The cost of one mile of double line to carry 1,200 tons per day of eight hours is roughly about £1,400, which is considerably less than any other form of railway. A good deal has been said lately about the dangers of electricity, but those who have any experience of electric lighting, or of power plants on the same principle as those used in a colliery, know that there is no danger whatever to be apprehended.

At the conclusion of Mr. Wallis' remarks, a vote of thanks, moved by the PRESIDENT, and duly seconded, was unanimously accorded to him.

It was resolved, upon the motion of Mr. W. B. SCOTT, seconded by Mr. JOHN HUGHES, "That the next general meeting be made special for the purpose of considering the question of joining the Federated Institution in a body."

A vote of thanks to the President for his inaugural address, moved by Mr. W. B. SCOTT, and seconded by Mr. LINDOP, was carried unanimously, and in acknowledging it the PRESIDENT said that he felt that in touching upon mines drainage matters he might be treading upon very delicate ground, and his desire was to draw a line between the character of the engineering operations, and the unfortunate financial circumstances by which they had been attended. He did not propose to enter into the second part of the subject. He believed that the situation was not nearly so bad as some people made it appear, but at the same time he had not devoted his attention so much to that part of it as to the engineering part.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

SPECIAL GENERAL MEETING,

APRIL 3RD, 1890.

MR. HENRY LEA, PRESIDENT, IN THE CHAIR.

The minutes of the Annual Meeting and Council Meeting were read, confirmed, and signed.

The SECRETARY read a letter of apology for inability to attend the meeting from Mr. E. B. Marten.

Mr. EDMUND HOWL was duly elected a Member of the Institute.

The chief business of this meeting was the consideration of the proposed alterations of Rule 5, raising the subscription from £1 1s. to £1 11s. 6d., so as to effect federation of all members, and of several of the rules as recommended by the Rules Committee.

The PRESIDENT—The circular calling the meeting states that it "is made special in accordance with the resolution and notice given at the Annual Meeting, to carry out the recommendation of the Council contained in the two last annual reports." I think that those of us who were at Sheffield will hardly require to have the advantages of this Federation impressed upon us. They seem to me to be so very obvious. There we met a number of men who had gone over in a body to the Federation, and the energy and interest displayed in the meeting, and the reception which we met with were beyond all praise, and I felt proud of belonging to a Federation which could appear in such force, and conduct its business in such a business-like manner. That, no doubt, will only be a sample of what we shall meet with in all parts of England at succeeding meetings. It seems to me it would be rather incongruous, if we ever have the pleasure of welcoming the Federated Institution to this city, that they should find that only a small portion of our members have joined. I cannot exactly say in what position those members who have not joined would appear, but I think it would be an incongruous one to our Institution to be the only one that has not joined the Federation bodily. I commend these few observations to your notice.

Mr. SOPWITH said that he was obliged to leave by an early train. He hoped members would take into consideration all the advantages that were to be obtained by joining the Federated Institution. He was quite sure that if they decided to join they would have every reason to be satisfied. The time at his disposal did not admit of his going into any special argument, but he hoped that if any difference of opinion were raised the matter would be adjourned. He moved that Rule 5 should be altered so as to make the subscription £1 11s. 6d. Mr. Sopwith then left the meeting.

The SECRETARY—The Vice-President quite approves of this proposal.

Mr. JOHN HUGHES—I have very much pleasure in seconding the proposition. I think it will be an advantage to every member to join, and I am sure that the benefit we shall receive will more than compensate us for the extra amount we shall have to pay.

Professor SMITH—Probably the Secretary can give us some information as to whether the carrying of this motion is at all likely to have the effect of withdrawing any subscriptions from the Institute. I hope it will not have that effect.

The SECRETARY—I have not heard any objection to the increased subscription, so that it should not be the cause of anyone withdrawing.

Mr. HAYWARD—How many members are there who have not joined the Federation?

The SECRETARY—About sixty.

Mr. JOHN HUGHES—About one-half.

The SECRETARY—I think this lukewarmness on the part of some of the members simply means that they have not considered the advantages. The proposed change really would reduce the Federation fee from 15s. to 10s. 6d. for those who have joined already.

Mr. GLENNIE—I should like to support this motion most cordially. I quite agree with the remarks the President has made upon the matter. I attended the meeting at Sheffield, and I think that everyone of us could not help feeling that the fact of belonging to an Institute which was federated with all the others of the country results in giving an extra standing to every member. We do not want to be spoken of as an Institute in which we have only got a certain number of members who care to join the Federation. We ought either to join as an Institute (and the fact of our being members of this Institute ought to make us members of the Federated Institution), or it would be better to have nothing to do with the matter.

After a few remarks by Mr. WARDLE and Mr. LINDOP in support of the proposal, the PRESIDENT put the resolution to the meeting, and it was carried unanimously.

The meeting then proceeded to consider the desirability of altering Rules 2, 4, and 5, so as "to admit of the introduction of Associates, consisting of under-managers or those in subordinate positions in any branches of engineering."

The PRESIDENT explained that whatever was resolved upon at this meeting would not be final, but would require confirmation at a subsequent meeting which would be made special for the purpose.

Mr. JOHN HUGHES asked whether there was a report from the gentlemen who were appointed to revise this rule, and whether they were all agreed upon this matter? He did not see what advantage the Institute would gain by admitting Associates or inviting under-managers to become members. He thought they were degenerating a little when they were inviting these gentlemen to take up their position in the Institute.

The PRESIDENT said that Mr. Sopwith was the Chairman of the Committee formed for the purpose of revising the rules. There had been no report sent in by the Committee, except a copy of the printed rules with certain alterations and additions, which he read to the meeting. Of course each rule would be open to free discussion.

The SECRETARY—The rule and the arrangement has been adopted by the North of England Institute since the admission under the Mines Regulation Act of second class certificates, and their rule in regard to it is this:—"Rule 6. Associates shall be persons acting as underviewers, under-managers, or in any other subordinate positions in mines, or employed in analagous positions in other branches of engineering." The same has been done at the Chesterfield Institute.

Mr. CLARKE—Would it be possible for an under-manager ever to be anything but an Associate? Would he always have to remain in that position?

The SECRETARY—Unless he obtained his first-class certificate I should take it so. Associates come in at a reduced rate at both of the Institutes referred to. They do not take part in the government of the Institute.

Mr. H. W. HUGHES said that he was one of the Rules Committee, and was rather surprised to find, on seeing the suggested alterations, that the class of Associates was proposed. The question was certainly discussed, but he thought that the feeling was rather against it than otherwise. Personally, he objected to it, and Mr. Sopwith assuredly did not speak in favour of it.

The PRESIDENT—I should like to ask whether there was not at the Rules Committee meeting a resolution put, and either rejected or carried, that this rule should be altered in the way proposed?

The SECRETARY said that the Rules Committee did not come to any decision upon the subject itself, but it was arranged that the matter should be submitted to the meeting for confirmation or otherwise, and it was really a recommendation from the Council, and had been approved by many of the members now objecting to it.

Mr. H. W. HUGHES proposed that the matter should slide till the next special meeting and then be considered.

Professor SMITH—It seems to me that it is brought forward for the consideration of this meeting without being recommended by the Committee.

The PRESIDENT said it was unfortunate that the Chairman of the Rules Committee (Mr. Sopwith) had been obliged to leave the meeting, but clearly apart from the Committee there was the resolution of the Council of 7th November, recommending the thing and fixing the next meeting to be special to pass it.

Mr. HAYWARD objected to the rule as proposed to be altered. It did not confine it even to the under-managers in a mine.

Mr. CLARKE—As the rule stands, it would be very hard to reject an under-manager when he has always conducted himself properly.

Mr. HAYWARD—They could not.

Mr. JOHN HUGHES moved that the old rule should stand as at present with the alteration in the age of Students from 21 to 23.

Mr. HAYWARD seconded the proposition.

The SECRETARY—Should it not be 25 instead of 23? I see the other Institutes say 25.

Mr. JOHN HUGHES having expressed his willingness to make it 25 instead of 23, the President put the resolution to the meeting and it was carried unanimously.

On the motion of Mr. JOHN HUGHES, seconded by Mr. WARDLE, it was unanimously resolved that in Rule 6 the fee for life members should be raised from £10 to £15.

Mr. WARDLE moved that Rule 8 be altered with regard to the mode of election of members, so that where the nomination is approved by the Council the election may be decided by show of hands at the following meeting.

This was seconded by Mr. GLENNIE, and carried unanimously.

Professor SMITH proposed that in Rules 1 and 4 the word "Civil" should be inserted, so as to read "Mining, Civil, or Mechanical Engineers."

Mr. NEWEY seconded this, and it was unanimously agreed to.

The next rule dealt with was No. 9, in which it was proposed to alter the mode of electing the officers of the Institute.

Mr. CLARKE doubted the wisdom of that portion of the rule which said that the three retiring Councillors should not be eligible for re-election until one year had elapsed. However active a man might have been on the Council he could not be

re-elected until he had been out of office one year. He scarcely saw why that should be so. With that exception he thought the rule a very good one.

Mr. H. W. HUGHES very much objected to a list of persons being selected by the Council.

Professor SMITH—Is it proposed that the four shall retire by rotation?

The SECRETARY—Yes.

Mr. H. W. HUGHES—What I meant when I proposed this altered rule was that the Council should consist of twelve members, and that four of those members should be elected every year, and when elected they should hold office for three years.

After considerable further discussion, the PRESIDENT asked whether it was likely that they could take a better form with regard to the election of officers than that adopted by the North of England Institute.

Mr. LINDOP did not think they could improve upon the North of England mode, and moved that it be adopted by this Institute.

Professor SMITH seconded, and it was approved.

Mr. H. W. HUGHES moved, and Mr. CLARKE seconded, that the last part of Rule 9, as read by the President, be approved. This was unanimously agreed to.

On the motion of Mr. H. W. HUGHES, seconded by Mr. COLE, it was resolved to vest the appointments of Treasurer and Secretary in the hands of the Council.

In Rule 11 "Mason College" was inserted for "Museum, Dudley."

Rule 14 was expunged.

The alterations of Rules 15 and 26 as to affixing notices in societies' rooms were agreed to.

It was resolved to insert the word "specially" in Rule 20.

With regard to Rule 21 (proposed power to publish the names of defaulters in regard to subscriptions), Mr. H. W. HUGHES moved that the rule as enforced by the Geological Society be adopted. This was seconded by Mr. FELLOWS, and carried unanimously.

The PRESIDENT moved, and Mr. CLARKE seconded, that the next meeting be made special to confirm the altered rules agreed upon at this meeting.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

MEETING HELD IN THE TOWN HALL, DERBY, 12TH APRIL, 1890.

MR. GEORGE LEWIS, PRESIDENT, IN THE CHAIR.

The following gentlemen were declared to have been duly elected by ballot:—

MEMBERS—

Mr. George Elce, Colliery Manager, Clayton-le-Mons, Accrington.
Mr. Robert Thornewill, Engineer, Engineering Works, Burton-on-Trent.

STUDENT—

Mr. Frank Swann, Linby, Nottingham.

The PRESIDENT, in opening the proceedings, said that having met once more in the town of Derby, he was pleased to see so good an attendance of members, for he was afraid that Saturday would be rather an inconvenient day for them to meet here. As they were aware no general meeting had been held for six months; the last one being merged into that of the Federated Institutes which met at Sheffield, and was attended by a considerable number of their members. He must say that looking upon that meeting as a whole it was a decided success. Taking the scientific part of the meeting he thought they would find that three very valuable papers were contributed: the one "On the Distribution of Energy over large areas in Mines by Electricity" was, so to speak, a host in itself. There was also the paper on "Coal-Getting by Machinery," which proved to be exceedingly interesting. Several questions were submitted which required their careful consideration. The paper on "The Geology of the Southern portion of the Yorkshire Coal-field" was also a most valuable and interesting contribution. A dinner followed, succeeded by a conversazione given by the Mayor and Master Cutler of Sheffield, and over 200 attended. He was convinced that the federation of Mining Institutes would prove to be the wisest and best course they could adopt for their benefit generally. The next meeting of the Federated Institutes would be held during the present month in London, and he hoped those who could attend would do so.

The first business was to consider any suggestions for alterations of rules or bye-laws. The Council had discussed the matter and come to the conclusion that no alteration was at present advisable.

In regard to the nominations for election of officers for the ensuing year, the Council suggested that for the future one nomination only for the office of President should be agreed upon. He believed this course was adopted by several other

important institutions, and for several reasons it recommended itself to them. Of course, it remained with the members to make any other suggestion, but the Council had unanimously agreed to recommend that Mr. J. P. Jackson be nominated for the Presidency during the coming year.

The Council had further agreed to nominate Messrs. G. E. Coke and W. Spencer for the position of Vice-Presidents, in addition to those now holding that office, who continue eligible under the rules. In like manner, Messrs. M. Deacon, H. Walters, H. Fisher, and G. Howe were suggested in addition for the office of Councillors.

The recommendations of the Council as above, with the addition of the name of Mr. P. M. Chester to the Councillors' list, were adopted.

DISCUSSION ON MR. DE RANCE'S PAPER ON "NOTES ON THE GEOLOGY OF THE MANCHESTER CANAL."

The PRESIDENT said those present at the excursion last August would remember that Mr. De Rance—who was the Government geologist officially engaged to investigate the district through which the Ship Canal passed, and particularly the disclosures resulting from the canal excavations—had at different points on the works favoured the party with *viva voce* information. The paper, which he had at that time prepared expressly for the occasion as a contribution to this Institution, had recently been printed in the Transactions of the Federated Institution, and was in the hands of members. He invited discussion.

The SECRETARY (Mr. W. F. Howard) said that he had invited Mr. De Rance to be present at to-day's meeting, but had not felt justified to press for his attendance.

Mr. M. H. MILLS thought the paper a most interesting one to institutions of that description, but as it referred to a district really outside their own, he did not suppose there was anyone present who would have anything definite to say upon it. If this meeting had been at Manchester, or in the Manchester district, there possibly might have been an interesting discussion. It was an extremely valuable paper to send to this Institution, and deserved their best thanks.

The PRESIDENT quite agreed with Mr. Mills that the paper being somewhat outside their district was not quite so interesting to them as it otherwise would have been; but he did not think anyone could read it without taking a great interest in the district with which it dealt. It seemed to him quite clear that some day or other—and the day might not be far distant—collieries would be sunk upon the banks of the Manchester Ship Canal. He thought there was very little doubt as to the extension of Coal-measures under the whole length of the district from Manchester to Liverpool; and Mr. De Rance also informed them they would be found at a depth not exceeding 400 yards. If that was so, the Coal-measures of the district were within a measurable distance, and consequently it seemed to him that the canal was destined in the future to become even a more important undertaking, and to themselves, as mining engineers, more interesting than it appeared to them during their visit. He was very much struck with the vast size of the canal. Unless they had actually inspected it, he did not think they could possibly appreciate the immensity of the undertaking. He was exceedingly pleased with the whole thing, so far as he was able to inspect it, and Mr. De Rance had given them a valuable paper on the subject. He thought their thanks were very justly due to Mr. De Rance for the pains he had evidently bestowed upon the paper, thoroughly understanding as he did the geology of the district. He (the President) was sure they were much obliged to him for his assistance during the entertaining journey they had down in that part of the country. He hoped they enjoyed themselves, and he would propose a hearty vote of thanks to Mr. De Rance, but that gentleman not being present he would ask the Secretary to convey the same to him.

Mr. A. H. STOKES seconded the proposition. He remarked that they were not only indebted to Mr. De Rance for the geological details in the paper, but also for the information he gave them about the canal itself. His assistance had materially enhanced the value of the day's excursion.

The resolution was carried with applause.

DISCUSSION ON MR. COKE'S PAPER ON "A RECENT BORING AT CHESTERFIELD WITH THE DIAMOND DRILL.

The PRESIDENT, in introducing this discussion, said they had now under consideration a geological subject entirely within their district.

Mr. A. H. STOKES said he was pleased to read the paper and see the section, but he would have been better pleased if Mr. Coke could have told them where the bore-hole stood in relation to the geological formation of the district. He presumed that was a point on which Mr. Coke would like the members of the Institute to express an opinion. It was interesting to know that a core of 7 inches long was obtained by the diamond boring in passing through a 4 feet 1 inch seam, but this was only 14 per cent. of core. He thought the President knew of a diamond boring machine having passed through a seam of coal about 4 feet 6 inches thick, which seam had been unnoticed in the boring. The seam was afterwards found when sinking to a lower bed of coal. He believed, however, that the bore-hole was put down when the machine bored an inch core, which appeared too small and unsuitable for coal. There was no doubt about the efficacy of the diamond boring through hard rocks, but for boring in coal it did not appear satisfactory. It would be very important if such machines could give them good and complete cores of coal, especially in such cases as the boring in Sussex, where coal had been recently found by boring. He would like Mr. Coke to explain why only 14 per cent. of coal core was got, and if he was satisfied that the core was a complete one or only in bits, and how he arrived at the conclusion that the seam was 4 feet 1 inch thick.

Mr. HENRY LEWIS said he almost entirely agreed with Mr. Stokes's remarks. A few years ago he had the work of putting down a boring hole, and engaged the Diamond Boring Company. He knew that a certain soft seam was there, with hard coal beneath. The diameter of the bore-hole was 1 inch. The borers went through the soft coal, which was a little over 3 feet in thickness, without proving it at all, and they even denied its existence. The reason was that the soft coal came up in such small particles that it was washed away by the pressure of water. The next seam, which was a very hard coal, they brought up the whole of the core perfect. This proved Mr. Stokes's contention that to be successful with the diamond boring machine the strata must consist of very hard coal or rock.

Mr. M. H. MILLS thought it was only fair to the Diamond Boring Company to say that he did not think there was anything at present to beat them. They showed splendid cores, both of coal seams and rocks. There was something in what Mr. Lewis had said, but at the present time there was nothing to beat the diamond rock boring machine.

Mr. H. LEWIS said it was very unsatisfactory that the boring company when they were engaged to prove a seam of coal should say it was not there when it was.

Mr. A. H. STOKES said Mr. Mills had referred to the machine as being satisfactory. There was no doubt that in hard rock, and in many of the Carboniferous rocks, the diamond drill was very satisfactory when they bored a large core, because they frequently got a fossil in the core, which indicated the geological horizon they were boring in. In unknown ground it was very valuable to know in what part of the geological strata they were boring; and when they were boring in the Coal-measures, and wanted to test the thickness and quality of the coal, it was most important that they should have, as far as possible, a complete core of the seam. When not boring for coal, probably there was no machine to beat the diamond

machine. He was in Sweden in 1872 when the Diamond Boring Machine Company were boring. They bored three holes within a few square feet, and the section of every one was different. That was with 1⅛ inch crown. When boring for coal at shallow depths he thought the old hand boring was preferable, because a good man would be able to tell by the feel the minute he struck coal, and then if he measured until he felt he had left it he would ascertain the exact thickness of the seam. In the diamond machine they had nothing of that kind. The first indication they had of the coal seam was the dirty water; but in such a seam as the Silkstone a dirty black water would be met with before reaching the coal seam itself, due to the coaly nature of the strata above the seam. This might mislead the men in charge of the machine, and make them think they were in the coal seam when they were not, hence it was important that they should get a large core, and plenty of it, when boring for coal.

Mr. G. E. COKE said he cordially agreed with what Mr. Stokes had said, and he thought the boring companies made a mistake in professing impossibilities. The particular core he saw was 7 inches long, and it was considered such a good specimen that it was sent to London. They were evidently not accustomed to get anything like 7 inches of coal. The sediment tube was fitted in order to collect any material not retained in the core tube; but he believed it could not be depended on. The strata became powdered up, and washed away with the water. He gave no opinion on the section. He hoped that gentlemen there, better acquainted with the district than himself, might decide the question. It was a reflection on boring in general that in a district where the section was so well-known, and a well-known coal cropping out not very far off, that there could be any difference of opinion as to a 4 feet seam. Some gentlemen who had seen the bore-hole considered the coal to be the Black Shale, whilst others averred that it was the Tupton Coal. As to Mr. H. Lewis's remarks about the seam of coal that was passed through unnoticed, it appeared quite possible to do so with the diamond drill, unless they were expecting such a seam of coal, when extra precautions could be taken. If the drill was going at full bore it might go through the seam without showing anything to guide the explorer, unless the water was rising to the surface, when the change of colour would be noticed. This being so, if they had boring going on, and the borers did not report the coal, they must not be sure it did not exist. He believed that in prospecting for coal it would be safer to go to the additional expense of lining the tube to ensure the water rising to the surface. In contributing this paper his main object was to have a record in the Proceedings of such an interesting event as the employment of the diamond drill in the neighbourhood. He did not profess to have had any great experience with this boring system. He might remark that the boring was for water, not for coal, so it was hardly fair to consider it a test of speed. It appeared to him that for deep borings the diamond drill was preferable. Thus the deep boring at Owthorpe was carried down some distance by another method, but afterwards the diamond drill was resorted to. He noticed that at the meeting of the Channel Tunnel Company, Sir E. Watkin asked for power to carry down the boring at Dover another 1,000 feet, and to employ the diamond drill.

In reply to some further remarks by Mr. Henry Lewis, Mr. COKE said Mr. Lewis had rather misunderstood him. What he said was that the diamond drill might go through unless they were expecting coal. If they drove at full speed with full water pressure, they might go through the seam without finding it, unless the hole was lined. He had heard of a case where a seam of coal was expected at a certain depth. The water was then turned off, and the machine moved slowly, and the seam was discovered, though another equally thick seam had been passed unnoticed. Of course the diamond would not work very long without water.

Mr. STOKES said that some time ago it was suggested by the Diamond Company's engineers, that whenever they came on coal, or directly they got the indication of the coal by the water washing, that they should withdraw the rods, take off the diamond crown, and put down a saw crown. He did not know whether they did this in Mr. Coke's case, but he knew the engineers suggested it in order that they could saw a circular core without the use of water, and in this way get a complete core of the coal seam. With regard to speed there was no doubt that a diamond machine could, in hard rock, beat all other kinds of boring instruments. He had known the drill go 304 feet in one week. In boring through hard sandstone the machine did well, and a fair amount of core was obtained; but in mixtures of sandstone and shale the indications were indefinite, and it was difficult to ascertain whether the sandstone or the shale was in greater quantity.

Mr. COKE said he had never heard of a circular saw, but had no doubt it might be used. As regards another of Mr. Stokes's remarks, the water would not come to the surface unless the hole was lined. If they arranged for the lining of the hole and forced the water to the top it would be a very good guide. He believed the diamond drill, for a short time, would go through soft rock as well as coal without requiring any water. The water was required to wash away the *débris* and keep the crown cool. The chargeman at Chesterfield recounted an incident, that when the machine was found to be going badly they drew the rods, and found the rods were leaking, and that no water had been forced down; no damage had been done, but the crown was very hot.

The PRESIDENT said before they closed the discussion he would like to be allowed to say a few words as to the merits of the diamond drill. It seemed to him that the gentlemen who had joined in the discussion were not very favourable towards it, and certainly it had its weak points, but up to the present he was very much inclined to think that it was the best machine they had for the purpose, more particularly when it was necessary to bore to any considerable depth. The deepest bore-holes in the country had been taken down by this machine, the one in Sussex, over 1,200 feet, successfully. The original idea was that coal would be found, and although this was not the case, they proved conclusively from the cores they brought out the strata through which they were passing. From that considerable depth they brought out fossils which materially assisted the geologists connected with the undertaking. He ventured to say that no other machine in the country could do the same thing, and he thought some little word of praise was due to the Diamond Boring Company. He thought that if a boring were to be put down, say to a depth of 150 yards, and did not require cores he would be inclined to fall back upon the old hand boring process. They were able by this means to define accurately the strata through which they were passing to a depth of 150 yards, but beyond that depth he was not aware of any better means than the diamond boring machine. That company had, like others, been cutting expenses rather too fine to make satisfactory work, for when they found they contracted to bore a hole for about £3 a yard to something like 300 yards deep they could not be making much profit out of it. The larger the core the more expensive the work would naturally be. As Mr. Coke had suggested, the company were going to bore near Dover, and he had no doubt they would be able to satisfactorily prove the strata in that part of the country, for he still had great faith in the diamond boring drill. He proposed with very great pleasure a vote of thanks to Mr. Coke for his interesting paper.

Mr. STOKES seconded, and hoped other gentlemen in the district who had in their possession similar interesting details as to boring would not hesitate to give the Institution their experience.

The resolution was carried *nem. con.*

Mr. LONGDEN said, as to Mr. Snell's paper, he went to Normanton to see the apparatus at work, and there would be similar electric apparatus at work in this district. In the paper of Mr. Wallis—Mr. Davis's electrician—on the same subject the writer told them he had had a current of 1,200 volts passing through him, and as he (Mr. Longden) had spoken to him that day, he was still alive and well. Now, in America it had been ascertained that 1,000 volts would cause instant death. The result was that the Americans had passed a law that instead of hanging people as a means of capital punishment, in future they were to send 1,000 volts through the man, and so cause instantaneous death. He would therefore like to know why 1,000 volts should be able to kill one man, and another could take 1,200 and seemed to be all right?

Mr. A. H. STOKES said the question which Mr. Longden had raised in connection with Mr. Russell's paper was very interesting, and perhaps there were some gentlemen present from the Sheffield or Unstone district who could give them a little information upon it. He knew a little about the Parkgate seam, but did not know that it split up into two in the way Mr. Longden had described. He was aware that the Silkstone at Sheffield and the Silkstone in Derbyshire were identically the same. There was always a characteristic bed of dirt between the two seams, except in one instance, which occurred at Shirland Colliery, and was well-known to Mr. Longden. In that instance the whole Silkstone seam, from top to bottom, for about 100 yards wide, was one mass of cannel coal. Probably when they met in London Mr Longden might give some particulars of this peculiar phenomenon. He would also like to know why the Parkgate, in Yorkshire, was a gas coal, and why, when it reached Derbyshire, it was not. The chief point he wished to speak about, however, was that of outbursts of gas, a subject upon which papers had been read at their sister institute of Barnsley. He thought the details of outbursts of gas were both instructive and interesting. There were members belonging to this Institute who could give their experience as to outbursts of gas. Some gentlemen in other institutes thought there was very little gas in the Midland district, and that they did not know what outbursts were. It was quite true that they seldom got any very serious explosions, but there were some members of the Institute who could tell that in three days, in one mine, a very short time since, 5,000,000 cubic feet of gas were given off. Another member could tell them that for some days 15,000 feet per minute of return air was fouled to such an extent that it fired in a safety-lamp at the bottom of the upcast shaft. That meant practically 1,000 feet of gas per minute. Both cases named were very large outbursts of gas. Such outbursts had not been recorded in the Transactions of this Institute, and he thought such records would make very valuable papers if the gentlemen connected with the mines in which they occurred would give the details to them, not only for the benefit of their own Institute, but for that of the other institutes in the Federation. He trusted the discussion of the papers would be adjourned so that they might have another opportunity of discussing them.

The PRESIDENT—That is so, Mr. Stokes. I wish to give Mr. Soar an opportunity of reading his paper, and I will adjourn the discussion on the other papers, as I think it will be better for them to be taken together.

Mr. CHARLES SOAR then read the following paper:—

SOAR'S PATENT COAL-LOWERING APPARATUS.

By Charles Soar.

It is well-known to colliery proprietors and managers and those having to deal with the screening of coal, that in many cases, especially where a tender coal has to be dealt with, it is properly *screened*, but to put it into wagons in the same perfect condition is a difficulty, because of the various heights of the wagons to be filled, owing to which the coal is broken by falling. The coal is not so valuable in the market because of the large percentage of small or dust in the wagon. To overcome this difficulty various plans have been tried. The most usual is to have a plate for the coal to slide down, the plate being raised or lowered to suit the size of truck being loaded. As is well-known, the plate is sometimes at such an angle that the coal slides down with great velocity; at other times, especially when the truck is nearly full, the coal has to be raked down. In either case there is great breakage of coal, particularly if the seam worked be friable.

The apparatus about to be described has none of these disadvantages. The coal has no greater distance to fall when the truck is empty than when full, or whether a large or small truck is being loaded. In either case the coal is put down as gently as if by hand.

The apparatus is used in connection with a picking band or sorting belt, on to which the coal is delivered from the screens, all "bats" and inferior coal being picked off the band. As the coal is falling from the end of the picking band the shelves of the lowering arrangement catch the coal and lower it into the truck.

The apparatus works in the following way:—A series of hinged shelves A are bolted to pitch chains B, which are made to work in the direction shown by the arrows by the driving chain C. This driving chain is actuated from the drum shaft of the picking band, and by means of the toothed gearing shown the speed of the chains B is kept strictly proportionate to the width of the plates on the picking band and the distance between the shelves, so that as the band delivers the coal from its end, a shelf is always in the proper position to receive it. For example, if the width of the plates on the picking band is 12 inches, and the shelves on the chains B are 18 inches apart, the gearing to drive the chain C must be in the ratio of 1½ to 1. The shelves, of course, can be placed at any distance apart to suit the size of coal to be dealt with.

The chain C is an endless one and passes from the driving wheel round the tension pulleys D D over the wheel of the top shaft E and round the bottom shaft F. The chains carrying the shelves are driven from the top shaft E.

The chain C being unable to slip on the driving wheel during the process of raising and lowering the apparatus, the position of the shelves with respect to the picking belt is not altered, all displacement of the chains and shelves taking place at the back, having the front shelves always working in unison with the picking band. By this arrangement it is not necessary to stop the picking band whilst the apparatus is being raised or lowered, and it is also immaterial whether it is raised only a few inches, or two or three feet, or more.

The top shaft, E, works in two slide blocks, G, which slide up and down between the fixed guide bars, H H. Bolted to the slide blocks are two distance bars, K K, which carry the bottom shaft, F, and are provided with means for taking up any slack in the chains, B B. Bars, L L, for the shelves to slide against, are placed in a suitable position.

The shelves, with the top and bottom shafts, are hung from the distance bars by chains passing over suitable chain wheels, M M, to prevent slipping, with weights to counterbalance the whole apparatus. On the same shaft as the chain wheels is a flat pulley, of suitable proportions, with a rope attached, which is worked by a small winch, O. The winch is provided with a ratchet wheel and pawl, so that the apparatus can be held in any position.

The apparatus has been at work for nine months.

In reply to questions by the PRESIDENT and Messrs. H. LEWIS and GEO. HEWITT,

Mr. SOAR stated that they had two machines at work, one for nuts and one for cobbles. At present they were passing 120 tons of cobbles and 60 tons of nuts per day, but this represented only a small proportion of the quantity that could be dealt with, the apparatus being capable of lowering as much coal as each picking band would pass. If 500 tons were put on the band, the apparatus would deal with it. All the coal was screened before passing on to the picking bands, in fact the picking bands were placed at the bottom of the screens, and one of the lowering apparatuses was at the end of each picking band. The coal was tipped on to the screens by a self-acting tippler, working sideways, which was actuated by a friction clutch.

Mr. H. LEWIS—I think this is a very important question, and we ought most decidedly to have the paper in our hands before we discuss it in the way it ought to be discussed. I propose that the discussion be adjourned until the paper has been in the hands of the members of the Institute.

Mr. G. HEWITT seconded, and the motion was carried.

The PRESIDENT—Mr. Soar, at the next meeting your paper will have been published in the ordinary way, and these gentlemen will have very great pleasure in telling you what they think of the appliance. I quite agree that it is a very important subject, and one worthy of very careful consideration, which I am sure the members of the Institute will give it.

Mr. G. HEWITT—Shall we have the paper published at the Federation meeting?

The PRESIDENT—For the 30th April—I am afraid not. I don't know what the Secretary thinks.

The SECRETARY said he could not tell. At the first meeting of the Publication Committee held in Sheffield it was discussed as to the time and interval between the publications, and it was agreed that the publication should take place every two, and not so long as three months, which had been the usual interval with them. Instead, it appeared to be longer, but this might be occasioned by the new arrangement not being in all respects in working order.

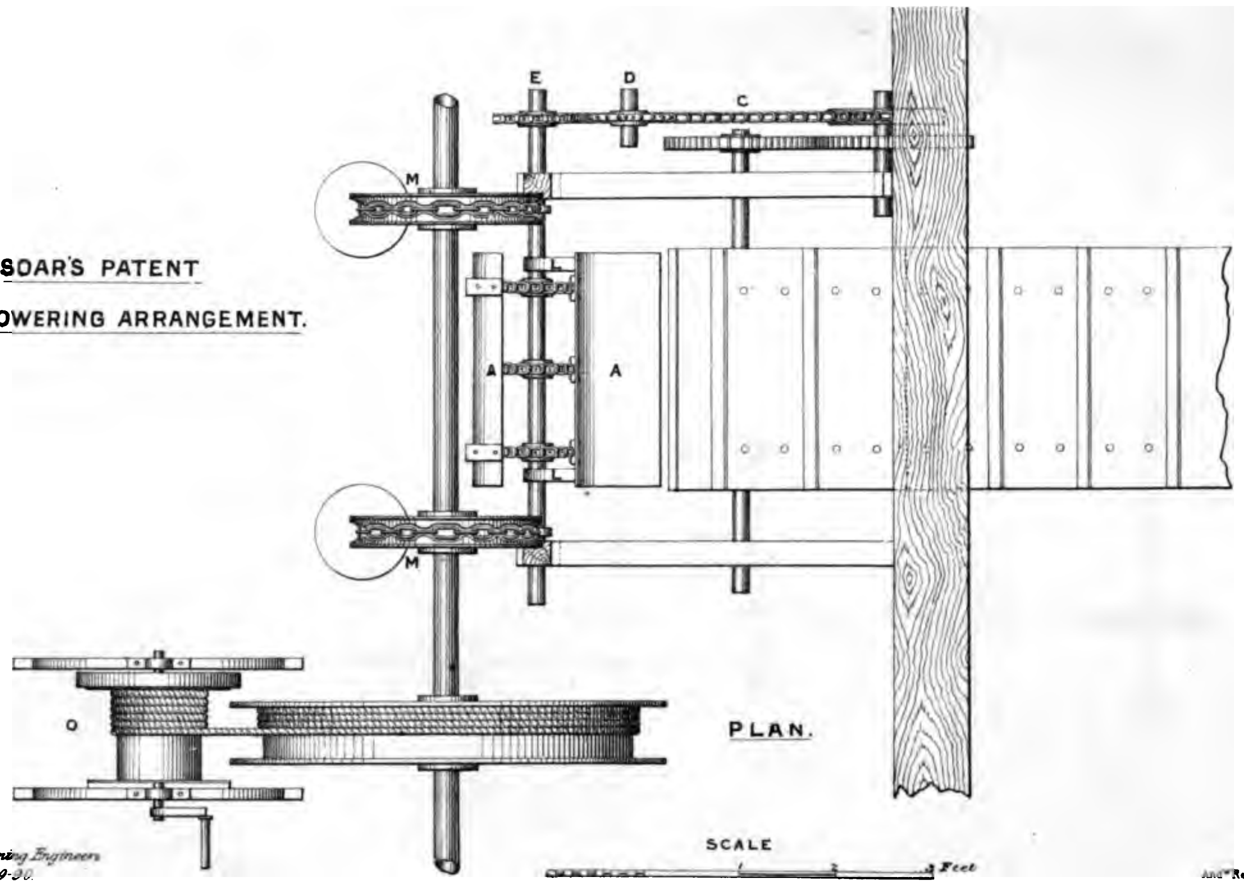
Mr. STOKES—Do you know when the members will receive the Transactions of the January proceedings in Sheffield?

The SECRETARY said he had no doubt that before the meeting in London, the Proceedings of the Sheffield meeting, with other matter, would be issued, and he had reason to believe in the form of Proceedings not Transactions.

Mr. STOKES thought there was a distinction, but there was very little difference between the Transactions and Proceedings. The distinction appeared to be in the coloured covers, and the difference was that one was in larger type than the other. He hoped the members of the Publication Committtee would look into it. The publication of one gentleman's paper in larger type than another gentleman's paper was an invidious distinction which in his opinion would act detrimentally to the welfare of the Federation.

SOAR'S PATENT

COAL LOWERING ARRANGEMENT.

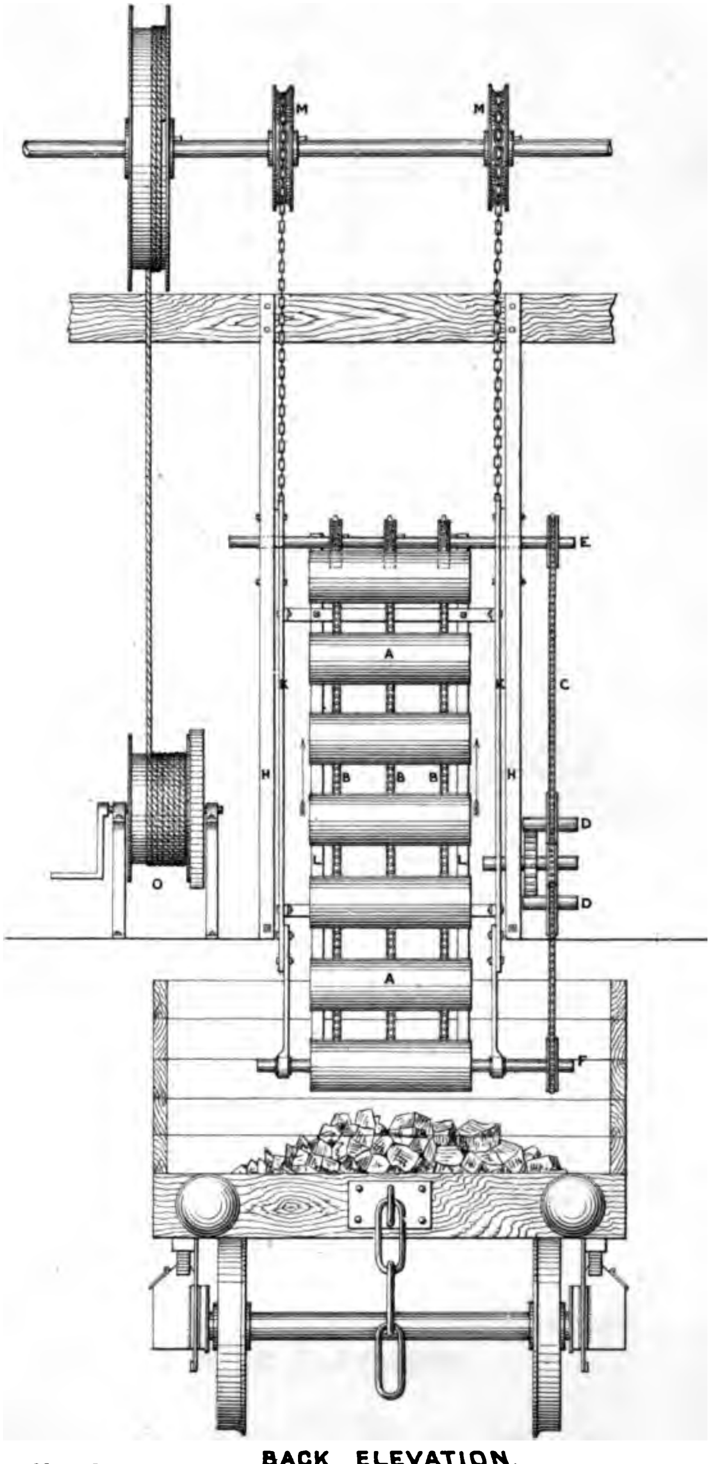


Federated Institution of Mining Engineers
Proceedings 1889-90.

Andw Reid, Sons & Co Lithos Newcastle

To illustrate Mr. Charles Soar's paper on "Soar's Patent Coal Lowering Apparatus."

SOAR'S PATENT COAL LOWERING ARRANGEMENT.



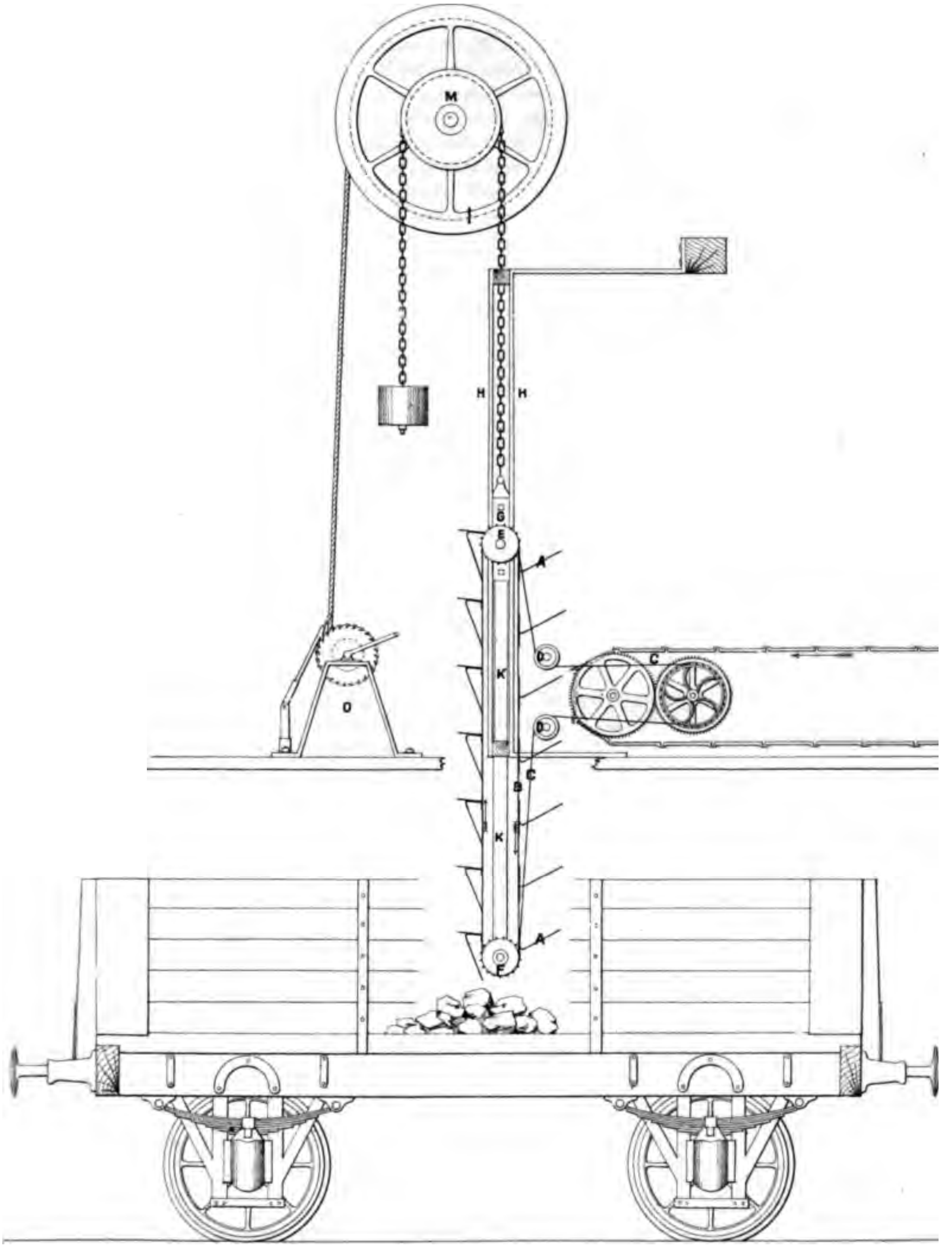
BACK ELEVATION.

Federated Institution of Mining Engineers
Proceedings 1889-90.

Andw Reid Sons & Co Lithos.

To illustrate Mr. Charles Soar's paper on "Soar's Patent Coal Lowering Apparatus."

SOAR'S PATENT COAL LOWERING ARRANGEMENT.



SIDE ELEVATION.

Andw Reid Sons & Co Lithos. Newcastle.

The **President** very much agreed with what Mr. Stokes said. He personally brought the matter before the Council, and he was glad to say they had one of their members on the Publication Committee—Mr. Mills—and he thought they might safely leave the matter in his hands. That concluded the business of the meeting, but perhaps the members would allow him to state that Messrs. Davis & Son had very kindly thrown open their electric lighting works, and they would be very happy to see any members there who wished to inspect them. Mr. Davis was present.

Mr. **Henry Davis** expressed the pleasure it would give him to see the members, if they would adjourn to the All Saints' Works, only a short distance away. He gave a brief epitome of what his firm had to show them.

Mr. A. H. **Stokes** remarked that some of Mr. Davis's electric lamps might be useful in case of gob fires in the Leicestershire and Warwickshire coal-fields. The lamp was much lighter than any other electric lamp he had seen, and was an exceedingly useful one. Those gentlemen who had a dynamo could have the lamps easily filled at night to carry about in the day or *vice versâ*. Those who had not dynamos could keep one for emergencies ready charged, or if they had an accident and needed the lamps, he had no doubt if they telegraphed to Mr. Davis he would send them off at once.

Mr. H. **Lewis**—What is the illuminating power of the lamps?

Mr. **Davis**—Four candle-power, and they will burn for ten or twelve hours.

Mr. H. **Lewis**—And about the cost?

Mr. **Davis**—I am not prepared with data. It has been suggested that we should keep a stock of lamps ready charged that would be useful in case of emergency. Upon receiving a request by wire, we would send the lamps required in good order by first passenger train.

Mr. H. **Lewis** to Mr. Stokes—And you advise us to use them in place of safety-lamps?

Mr. **Stokes**—Oh, no.

Mr. H. **Lewis**—Not you.

Mr. **Davis** said in cases of accident they would be very valuable, but at present for ordinary use in the pit they were too expensive. In case of fire they could be used where it was not safe for men to go.

Mr. H. **Lewis**—If it is not safe for the men, no lamp ought to go.

In answer to the Chairman, Mr. **Davis** said he would send a lamp down to the next meeting.

The members then adjourned to Messrs. John Davis & Son's All Saints' Works, where they inspected electric lighting plant, consisting of a Marshall engine, dynamos, accumulators, and distributing and regulating switches for the supply of current to public and private buildings in the centre of the town. Applications of electricity for the transmission of power were also illustrated. A motor was driving a small donkey pump for the purpose of filling the steam boiler.

A novel feature in electric signalling was a secondary battery, claimed to possess many advantages over the primary or voltaic battery for colliery signalling, where a dynamo is employed which can recharge it at stated intervals.

A collection of miners' electric safety-lamps attracted considerable attention, and it was pointed out by Mr. Stokes, H.M. Inspector of Mines, that such lamps would be most useful to assist search parties, and for clearing away *débris* after accidents in mines. Magnetic signal bells, requiring no battery at all, were exhibited, and a large assortment of special fittings for protecting electric lamps for colliery use was shown.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE OFFICES OF THE INSTITUTION OF CIVIL ENGINEERS, 25, GREAT GEORGE STREET, WESTMINSTER, ON WEDNESDAY, APRIL 30TH, 1890.

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY, having announced the arrangements for the following day in regard to the visit to the Mint, etc., said he was happy to state that the South Staffordshire Institute had now joined the Federation entirely; hitherto only a portion of the members were also members of the Federated Institution. With regard to the Proceedings of the Council, it had been agreed that the next General Meeting should be held during the month of July, at Edinburgh, as being the centre of the Newcastle district for this occasion only. It was proposed that the September Meeting should be in the Nottingham district as representing the Chesterfield centre.

The PRESIDENT said he was happy to announce that Mr. Topley would read a paper on coal in Kent, an interesting subject, on which they would all be glad to know more than they did at present.

Mr. W. TOPLEY, F.R.S., etc., read a paper on "Coal in Kent."*

The PRESIDENT announced that Mr. G. B. Walker's paper "On Coal-Cutting Machinery" was open for discussion. Some of the plates which should have accompanied this paper would appear in the next part. Perhaps Mr. Walker would say if he had anything further to add to the paper.

Mr. G. B. WALKER—Nothing at all.

The SECRETARY suggested that as the paper was not complete without the plates it would be well to defer the discussion on the paper, which was very valuable.

Mr. CHAMBERS—I think we should be likely to get a better discussion.

Discussion was accordingly adjourned.

Mr. R. Russell's paper on "The Geology of the Southern portion of the Yorkshire Coal-field" was open for discussion.

The SECRETARY stated that Mr. Russell was in the Isle of Man. In his absence any questions which might be asked would be forwarded to the author, and answers communicated by correspondence.

* This paper not having yet been received, its publication must, with that of the long and interesting discussion upon it, be postponed.—EDITOR. 30th August, 1890.

There being no remarks offered on this paper, the President announced that Mr. Smith would describe and exhibit an interesting apparatus for indicating temperatures.

Mr. A. SMITH described an instrument to which he said his attention had been drawn in Birmingham, and which he had received permission to exhibit at this meeting. It was called "The Patent Adjustable Automatic Fire Alarm and Heat Indicator," and consisted of sensitive diaphragms for electrically giving an alarm when the temperature of a room or building in which it was placed rose to the heat indicated by the adjustable index finger, which had a range from freezing point to upwards of 200 degrees Fahrenheit.

The instrument was exhibited and experimented upon.

Mr. A. L. STEAVENSON—What we want it for is to put it in the middle of coal heaps, where there is considerable heat.

Mr. SMITH—Yes, it is very useful when you want to detect any increased temperature before a fire takes place.

This concluded the business, and arrangements having been made for visits to the different places open to members the following day, the meeting terminated.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE VICTORIA HOTEL, SHEFFIELD, ON TUESDAY, MAY 13TH, 1890.

MR. C. E. RHODES, PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The SECRETARY—With reference to the resolution in the minutes on the delay in the issue of the Transactions, I sent it to the Hon. Sec. of the Federated Institution, who wrote saying the delay was due to his illness, which had made it impossible for him to get through the work. The Transactions were out in time for the meeting of the Federation in London.

Mr. THOMAS ANDREWS, F.R.S., M. Inst. C.E., read the following paper on "The Action of Tidal Streams on Metals."

THE ACTION OF TIDAL STREAMS ON METALS.

By Thos. Andrews, F.R.S.S. L. & E., M. Inst. C.E., F.G.S.,
Telford Medallist and Telford Prizeman, Wortley Iron Works, near Sheffield.

A few years ago the author made a brief communication to the Royal Society relating to "Tidal Action on Metals," so as to claim priority in the discovery of this peculiar corrosive influence. Having also made more extended experiments, he considered it might be both desirable and useful to present his observations to the Midland Institute of Mining and Civil Engineers.

The phenomena presented by the disposition of the waters in the length of a large tidal stream during diffusion of the salt and fresh water afford a subject of study possessing much scientific interest in many ways. For present purposes, however, it will be sufficient to investigate the effects arising from difference of salinity between the bottom and surface waters, which bear intimately on the stability of all marine ironwork structures.

The effect of the gradual rise and consequent inward flow of salt water, and the outward flow of fresh water, has a general tendency to arrange the waters of a tidal stream into long, overlapping, wedge-like layers or formations, the lower containing denser salt water and the upper more fresh water. This disposition of the waters is modified very considerably by currents, inter-diffusion, and numerous other conditions. The arrangement and diffusion of the salt and fresh water may not necessarily at all places in the stream be of an even character, almost isolated bodies of salt and fresh water not improbably accumulating in the numerous creeks, basins, or other indentations along the shores. Moreover the general contour of a stream; the influence of rainy or dry seasons (affecting the proportion of fresh water); the fact of the estuary being either long, deep, and narrow, affording little fall, or, on the contrary, of a wide, shallow character; the states and times of tide, etc.; and many other circumstances variously modify the diffusion results.

From the foregoing it will, however, be readily understood that the upper and lower portions of a metal structure or vessel, etc., although composed throughout of the same metal, would be exposed to electrolytic disintegration from the galvanic action of two solutions of different composition after the manner indicated in the sketch, Fig. 1.

An analytical examination of the composition of the waters throughout the length of a tidal stream during diffusion of salt and fresh water, consequent on tidal action, reveals a very considerable difference in the proportion of saline constituents, between the water at the surface and that at the bottom, during certain times of tide. This difference amounts sometimes to near 100 per cent., and it may frequently be either much greater or less according to tidal fluctuations.

This fact constitutes the basis of the investigation which the author undertook to obtain some approximate quantitative measurement of the resultant electromotive force, etc., arising from such difference of potential.

It is known that a current is set up when a bar or plate of the same metal is immersed in two dissimilar solutions in contact, one capable of acting readily upon the metal, the other having little or no action on it, the whole forming a circuit.

The current continues until diffusion renders the composition of the solutions uniform, after which a reverse current may not unfrequently be observed arising from the previous unequal action of the solutions on the metal.

The series of groups of metals employed in this investigation, viz., wrought irons, various steels and cast metals, etc., were especially selected, in order to render the research of more practical value.

The two dissimilar solutions used were sea water and distilled water.

A continuous supply of sea water was obtained for the experiments from Filey Bay.

The following rough sketch (Fig. 1) will render manifest the probable lines of direction of the electric current (flowing all round the column or bar) set up in any metallic bar, column, or erection, by difference of potential between the surface and bottom waters in a tidal stream, the lower portion being exposed to the action of the denser salt water, the upper portion being in the less saline surface water:—

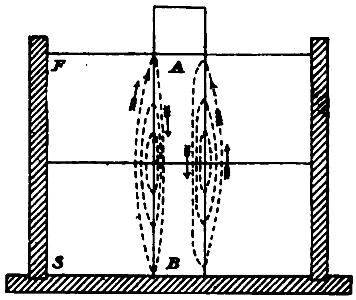


FIG. 1.

F, surface water, containing less saline matter. S, denser salt water at the bottom. The upper portion A is in the electro-negative position; the lower portion B is in the electro-positive position.

It would not, however, be practicable to measure the resultant electromotive force by attaching the ends of the metallic rod thus exposed to the action of dissimilar solutions to a galvanometer, because the current would be circulating through the bar (forming the shortest circuit of least resistance) in the manner above indicated. A galvanometer thus connected would constitute such a very disproportionate arm of the divided circuit as only to receive a very minute fraction of the current. Moreover, the regular and steady diffusion of the dissimilar solutions, after the manner of tidal periods, could not be effected by such an arrangement. The author therefore decided to divide each metal bar, and devised the arrangement described below for carrying out this research.

The experiments were made on large cylindrical bars of each of the following metals, of known chemical composition and specific gravity. Every bar was $2\frac{31}{32}$ inches diameter, carefully turned and polished quite bright, the metals being each specially prepared throughout for these observations.

A careful selection was made with reference to the percentage of combined carbon, specimens containing the highest and lowest being taken in order that extreme results in each case might be arrived at. The descriptive terms "soft" and "hard" have reference solely to percentages of combined carbon.

This size and round form of bar was employed in preference to plates, in order that, as near as practicable, a uniform temper and molecular structure might be obtained. Such a form is probably less liable than any other to alteration in molecular structure from the mechanical processes of its manufacture, the pressure in manipulation being always uniformly towards the centre of the bars; preference was therefore given to this form and size.

Such dimensions also gave a large surface of exposure, tending to minimise effects arising from minute surface defects, to prevent which, however, the greatest care was exercised in preparing the metals.

The steel and iron bars in each case were prepared from the same ingot, or blown and sawn into equal lengths when finished, so that the bars of the same metal (turned and finished) were identically of one composition, etc. The same exact care was exercised in the preparation of the cast metal bars.

The chemical composition and specific gravities of the metals are shown in Table A.

METHOD OF EXPERIMENTATION.

The experiments were conducted as follows, in precisely the same manner in each case for comparison:—

For the purposes of this research the cells (Fig. 2) were constructed so that the diffusion effects, electromotive force, etc., observed should approximate to those obtaining during a tidal period of six hours.

A strong wooden box (Fig. 2) was divided into two equal compartments, the partition containing at the lower end a porous diaphragm of chamois leather, to allow of a suitable diffusion between the solutions.

Two bars from the same piece of metal (of the same composition), polished bright, and exactly $2\frac{31}{32}$ inches diameter, were placed in the cells exactly at equal distances apart in each case ($1\frac{9}{32}$ inches), one bar in partition A and the other bar in partition B, the bars being attached to the galvanometer No. 1. The partitions A and B were then simultaneously carefully filled up to a depth of 12 inches, the one with sea water, the other with distilled water, and careful telescopic readings taken of the time changes in the deflections of the galvanometer No. 1 regularly during the tidal period of six hours.

The arrangement is shown in the accompanying sketch.

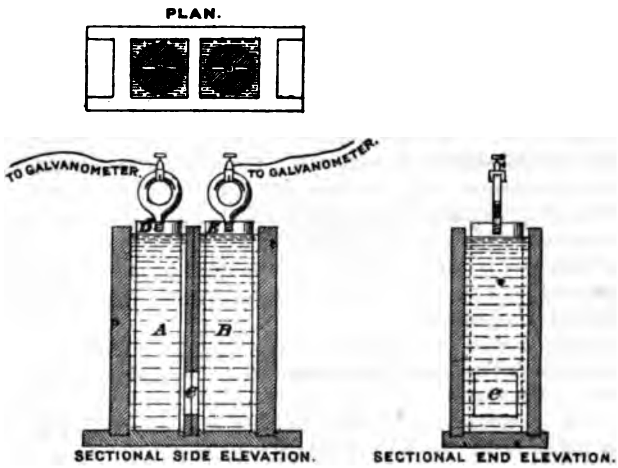


FIG. 2.

Diffusion cells. (Scale 1 inch = 1 foot.)

A, the division of the box containing sea water. B, the division of the box containing distilled water. C, porous diaphragm of chamois leather dividing the two solutions. D, one bar of the metal immersed in sea water. E, the other bar of the same metal immersed in distilled water.

The difference in level between the solutions in the cells, caused by the greater specific gravity of the sea water, assisted diffusion, thus approximating to the current pressures exerted in rivers by the tidal flow.

To render the application of these experiments as practical as possible, the observations of the electromotive force and time changes of resistance during diffusion were regularly taken at intervals stated on the tables over tidal periods of six hours, so as to afford an approximation to the effects produced by alternating diffusion of salt and fresh water during the tidal changes of a tidal river.

The galvanometer, No. 1, with its accessories, resistance coils, etc., employed in these experiments was a delicate astatic one (by Messrs. Elliott Bros.), suspended needles, large mirrored dial, and it was also arranged to work as a minor galvanometer. It was constructed as to resistance, etc., specially to suit this research.

The resistance of the galvanometer at 20 degrees centigrade was 521 ohms.

A Daniell's cell through a total resistance of 10,624 ohms gave a deflection of 15 degrees.

The author's laboratory was maintained as near as practicable at the above temperature during the whole of the observations for this paper.

The galvanometer was carefully calibrated throughout on the spot at the commencement of the research with a Daniell's cell (copper, in cold saturated cupric sulphate solution, with crystals; the zinc, in cold saturated zinc sulphate solution) in circuit, and the constancy of the instrument afterwards frequently verified.

All the readings throughout were carefully taken with a reading telescope.

Another astatic galvanometer, No. 2 (suspended needles), of lower resistance was used for taking the time changes in the resistance of the cells (Fig. 2) by the first fling method as described further on.

The results of the observations giving the electromotive force, etc., and the time changes of resistance in the cells (Fig. 2) during diffusion are recorded in the following Tables B, C, D, E, F, G, and on Plate I. The electromotive force was calculated from the ascertained resistances in circuit in conjunction with the known calibration of the galvanometer, No. 1, which was used for this part of the research.

For ascertaining the comparative behaviour of the various metals employed, the author has given the average, together with the highest electromotive force, noted during the observations in each case. The observations having been made in exactly the same manner and at the same periods of time (from the commencement of the experiment), this method consequently affords a basis of comparison.

Difficulties were experienced in determining the resistance in the cells (Fig. 2) which was momentarily such an inconstant quantity, owing to diffusion between the two solutions, and the difficulty was further increased by polarisation when the Daniell's cell was connected.

After conferring with Professor J. V. Jones, B.Sc., B.A., Firth College, on this point, recourse was had in separate experiments to the method of rapidly alternating the direction of the current sent through the cells (Fig. 2) (it being first sent in the direction of the current from those cells, then reversed), and reading from the first fling of the galvanometer, No. 2, by the aid of a reading telescope.

A number of preliminary experiments were made with various steel, and also with copper, plates to test the applicability of this method, and the author proceeded to determine the whole series of changing resistances (in the cells, Fig. 2) in this manner.

The arrangement will be understood on referring to Fig. 3.

It may not, perhaps, be obtrusive to describe in detail the method as ultimately worked.

A Daniell's cell (D) was placed in circuit connected with the astatic galvanometer (G), the two wires terminating in cups of mercury (M M); the box of resistance coils (R) was also in circuit; two steel bars (of precisely the same metal) in the two dissimilar solutions (sea water and distilled water in the cells C) were connected with the mercury cups, so that when contact was made the current from the Daniell's cell (D) was made to pass through the steel bars in the cells (C) in either direction as required.

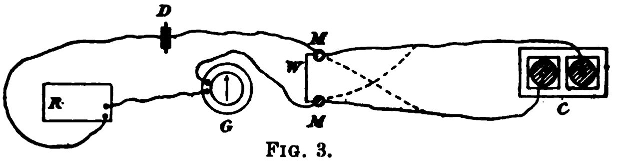


FIG. 3.

The moment the two cells (C) were filled with the dissimilar solutions (the astatic galvanometer, No. 2, being at rest), contact was made, and the extent of the first fling of the needle carefully taken through a reading telescope, the resultant deflections from the current first sent in the direction of that from the cells, and then the reverse being taken as rapidly as possible during the six hours' duration of each tidal experiment. An observation each way being made about every half minute.

The rapid reversal of the direction of the current sent through the cell was effected by alternately crossing the wires, as shown by the dotted lines on Fig. 3. By this arrangement all risk of disturbing the diffusing solutions in the cells was obviated. The movable connection (W) was used for completing the battery circuit when the cells (C) were disconnected, in order to ascertain the resistance as under:—

The resistance values of the deflections thus observed were ascertained by comparison with known resistances in the box, while the same Daniell's cell was in circuit; the constancy of the Daniell's cell was also frequently verified during the observations.

The time changes in the resistance of the diffusing solutions ascertained by this first fling method, are shown in the curve of resistances given in Fig. 4, which is constructed from the average of a series of six carefully repeated experiments, each extending over the tidal period of six hours. This resistance curve is the result of above 4,300 observations.

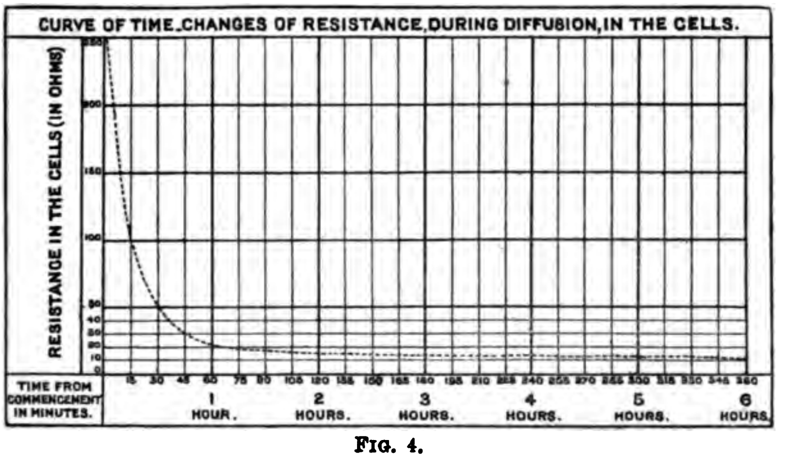


FIG. 4.

The resistance of the diaphragm itself (C) in the cells (Fig. 2) was found to be 3¼ ohms, which, of course, is included in the curve.

The method just described of ascertaining the time changes in the resistance by diffusion of the two dissimilar solutions in contact was found to be of great service in minimising the effects of polarisation. It also affords one means of simultaneously ascertaining the electromotive force, and has sometimes thus been used as a check method by the author.

TABLE A.

ANALYSES OF THE WROUGHT IRONS, VARIOUS STEELS, AND CAST METALS EMPLOYED.

Description.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.	Iron (by difference).	Total.	Specific Gravity.
Wrought iron	..	none.	·392	·034	·270	·194	99·110	100·000	7·590
"Soft" Bessemer steel ..	..	·150	·009	·112	·088	·468	99·173	100·000	7·853
"Soft" Siemens-Martin steel	..	·230	·014	·100	·075	·698	98·883	100·000	7·856
"Soft" cast steel	..	·450	·016	·027	·048	·086	99·373	100·000	7·863
"Hard" Siemens-Martin steel	..	·460	·107	·023	·075	·972	98·363	100·000	7·845
"Hard" Bessemer steel ..	..	·480	·121	·096	·089	·684	98·530	100·000	7·838
"Hard" cast steel .. .	·259*	1·190*	·175	·063	·019	·396	97·898	100·000	7·805
Cast metal No. 1	2·780*	·390*	2·340	·090	·580	·450	93·370	100·000	7·206
Cast metal No. 2	2·620*	·670*	1·940	·090	·950	·520	93·210	100·000	7·134

* Combined carbon in these samples was determined by combustion, and in the other samples by the colour test.

The wrought irons were made from selected clean scrap iron.

BLE B.—THE ELECTROMOTIVE FORCE, ETC., DURING DIFFUSION OF SEA WATER AND DISTILLED WATER, ACTING ON THE SAME METAL OVER TIDAL PERIODS OF SIX HOURS.

Wrought Iron Rolled Bars (bright). (See Fig 2.)				Wrought Iron Hammered Bars (bright). (See Fig. 2.)				
1	2	3	4	1	2	3	4	
ction lvan- er in ees at rvals ne as ted.	Electro-Chemical position of the Wrought Iron Rolled Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electromotive Force in Volts.	Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the Wrought Iron Hammered Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electromotive Force in Volts.	Time from commencement of Experiment. H. M.
50	P	243	0·015	3·00	N	243	0·016	....
50	P	202	0·028	1·25	N	202	0·006	0 2½
50	P	192	0·038	0·50	P	192	0·002	0 5
75	P	167	0·052	2·00	P	167	0·011	0 7½
25	P	148	0·074	3·00	P	148	0·014	0 10
25	P	113	0·082	4·00	P	113	0·017	0 12½
75	P	102	0·091	5·00	P	102	0·021	0 15
75	P	85	0·092	6·00	P	85	0·026	0 17½
75	P	76	0·095	6·75	P	76	0·029	0 20
00	P	70	0·095	7·25	P	70	0·030	0 22½
10	P	64	0·094	8·00	P	64	0·033	0 25
10	P	57	0·093	8·25	P	57	0·034	0 27½
10	P	51	0·092	8·75	P	51	0·035	0 30
10	P	46	0·091	9·00	P	46	0·036	0 32½
00	P	42	0·090	9·00	P	42	0·035	0 35
90	P	39	0·090	9·00	P	39	0·035	0 37½
60	P	36	0·088	9·00	P	36	0·035	0 40
25	P	34	0·086	9·00	P	34	0.035	0 42½
00	P	32	0·085	8·90	P	32	0·035	0 45
75	P	30	0·084	8·90	P	30	0·034	0 47½
25	P	29	0·082	8·75	P	29	0·034	0 50
00	P	27	0·081	8·50	P	27	0·033	0 52½
75	P	26	0·080	8·25	P	26	0·032	0 55
50	P	26	0·079	8·10	P	26	0·031	0 57½
25	P	25	0·078	8·00	P	25	0·030	1 0
00	P	24	0·077	7·90	P	24	0·030	1 2½
75	P	23	0·076	7·75	P	23	0·029	1 5
40	P	22	0·074	7·50	P	22	0·029	1 7½
00	P	21	0·073	7·25	P	21	0·028	1 10
50	P	21	0·071	7·10	P	21	0·027	1 12½
00	P	20	0·069	6·90	P	20	0·027	1 15
75	P	20	0·068	6·80	P	20	0·027	1 17½
50	P	19	0·067	6·75	P	19	0·026	1 20
25	P	19	0·066	6·50	P	19	0·026	1 22½
00	P	18	0·065	6·25	P	18	0·024	1 25
60	P	18	0·064	6·10	P	18	0·024	1 27½
25	P	17	0·063	6·00	P	17	0·023	1 30
00	P	17	0·062	6·00	P	17	0·023	1 32½
75	P	17	0·061	5·90	P	17	0·023	1 35
50	P	17	0·060	5·80	P	17	0·022	1 37½
25	P	17	0·059	5·75	P	17	0·022	1 40
10	P	17	0·059	5·50	P	17	0·021	1 42½
90	P	17	0·058	5·25	P	17	0·019	1 45
70	P	17	0·057	5·10	P	17	0·018	1 47½
50	P	17	0·056	5·00	P	17	0·018	1 50
30	P	17	0·056	4·90	P	17	0·017	1 52½
10	P	16	0·055	4·75	P	16	0·017	1 55
90	P	16	0·054	4·60	P	16	0·016	1 57½
70	P	16	0·054	4·50	P	16	0·016	2 0
50	P	16	0·053	4·30	P	16	0·015	2 2½
30	P	15	0·052	4·10	P	15	0·015	2 5
00	P	15	0·051	4·00	P	15	0·014	2 7½
80	P	15	0·051	3·90	P	15	0·014	2 10
60	P	15	0·050	3·70	P	15	0·013	2 12½
40	P	15	0·050	3·50	P	15	0·013	2 15
20	P	15	0·049	3·30	P	15	0·012	2 17½
00	P	14	0·048	3·10	P	14	0·012	2 20
75	P	14	0·047	3·00	P	14	0·012	2 22½
50	P	14	0·046	2·80	P	14	0·011	2 25
30	P	14	0·045	2·60	P	14	0·011	2 27½
10	P	14	0·045	2·50	P	14	0·010	2 30
90	P	14	0·044	2·50	P	14	0·010	2 32½
70	P	13	0·043	2·40	P	13	0·010	2 35
50	P	13	0·043	2·30	P	13	0·010	2 37½
25	P	13	0·042	2.25	P	13	0·009	2 40
00	P	13	0·041	2·29	P	13	0·009	2 42½
75	P	13	0·041	2·10	P	13	0·009	2 45
50	P	13	0·040	2·10	P	13	0·009	2 47½
25	P	13	0·039	2·00	P	13	0·009	2 50
10	P	13	0·039	1·90	P	13	0·008	2 52½
90	P	13	0·038	1·80	P	13	0·007	2 55
70	P	13	0·037	1·75	P	13	0·007	2 57½
50	P	13	0·036	1·70	P	13	0·007	3 0
90	P	13	0·033	1·60	P	13	0·006	3 10
30	P	13	0·031	1·50	P	13	0·006	3 20
75	P	13	0·029	1·40	P	13	0·005	3 30
20	P	13	0·027	1·30	P	13	0·005	3 40
60	P	13	0·026	1·10	P	13	0·004	3 50
00	P	12	0·023	1·00	P	12	0·004	4 0
60	P	12	0·021	1·00	P	12	0·004	4 10
30	P	12	0·019	1·00	P	12	0·004	4 20
00	P	12	0·018	1·00	P	12	0·004	4 30
60	P	12	0·016	1·00	P	12	0·004	4 40
30	P	12	0·015	1·00	P	12	0·004	4 50
00	P	12	0·014	1·00	P	12	0·004	5 0
60	P	12	0·013	1·10	P	12	0·004	5 10
20	P	12	0·012	1·10	P	12	0·004	5 20
75	P	12	0·011	1·10	P	12	0·004	5 30
60	P	12	0·011	1·25	P	12	0·005	5 40
40	P	12	0·010	1·40	P	12	0·005	5 50
25	P	12	0·009	1·50	P	12	0·006	6 0

atest *E.M.F. observed, 0·095 of a Volt.*
rage *E.M.F.* „ *0·054* „

Greatest E.M.F. observed, 0·036 of a Volt.
Average E.M.F. „ 0·017 „

Table C.—The Electromotive Force, etc., during Diffusion of Sea Water and Distilled Water, acting on the same Metal over Tidal Periods of Six Hours.

"Soft" Bessemer Steel (bright). (See Fig. 2.)				"Hard" Bessemer Steel (bright). (See Fig. 2.)				
1	2	3	4	1	2	3	4	
Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the "Soft" Bessemer Steel Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electromotive Force in Volts.	Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the "Hard" Bessemer Steel Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electromotive Force in Volts.	Time from commencement of Experiment. H. M.
7·50	P	243	0·040	15·50	P	243	0·080	....
8·75	P	202	0·044	18·75	P	202	0·091	0 2½
10·50	P	192	0·053	20·50	P	192	0·098	0 5
12·40	P	167	0·059	22·75	P	167	0·105	0 7½
14·00	P	148	0·064	25·25	P	148	0·113	0 10
14·60	P	113	0·063	27·25	P	113	0·112	0 12½
14·25	P	102	0·061	27·00	P	102	0·114	0 15
13·60	P	85	0·057	27·90	P	85	0·114	0 17½
13·10	P	76	0·054	28·50	P	76	0·116	0 20
12·90	P	70	0·053	29·10	P	70	0·117	0 22½
12·60	P	64	0·051	29·75	P	64	0·119	0 25
12·50	P	57	0·050	30·00	P	57	0·119	0 27½
12·50	P	51	0·049	30·40	P	51	0·119	0 30
12·40	P	46	0·048	31·20	P	46	0·122	0 32½
12·25	P	42	0·048	32·00	P	42	0·124	0 35
12·00	P	39	0·046	32·50	P	39	0·126	0 37½
11·75	P	36	0·045	33·00	P	36	0·128	0 40
11·50	P	34	0·044	33·50	P	34	0·130	0 42½
11·25	P	32	0·043	34·00	P	32	0·132	0 45
11·00	P	30	0·043	34·10	P	30	0·132	0 47½
10·50	P	29	0·041	34·25	P	29	0·132	0 50
10·50	P	27	0·041	34·50	P	27	0·133	0 52½
10·25	P	26	0·040	34·75	P	26	0·134	0 55
10·00	P	26	0·039	34·90	P	26	0·135	0 57½
9·50	P	25	0·037	34·90	P	25	0·134	1 0
9·25	P	24	0·035	35·00	P	24	0·135	1 2½
9·00	P	23	0·034	35·00	P	23	0·134	1 5
8·75	P	22	0·034	34·90	P	22	0·134	1 7½
8·50	P	21	0·033	34·90	P	21	0·133	1 10
8·25	P	21	0·031	34·90	P	21	0·133	1 12½
8·00	P	20	0·030	34·90	P	20	0·133	1 15
7·75	P	20	0·029	34·80	P	20	0·133	1 17½
7·50	P	19	0·028	34·75	P	19	0·132	1 20
7·40	P	19	0·028	34·70	P	19	0·132	1 22½
7·25	P	18	0·028	34·60	P	18	0·131	1 25
7·00	P	18	0·027	34·50	P	18	0·131	1 27½
6·75	P	17	0·026	34·40	P	17	0·130	1 30
6·50	P	17	0·026	34·25	P	17	0·129	1 32½
6·25	P	17	0·024	34·10	P	17	0·129	1 35
6·00	P	17	0·023	34·10	P	17	0·129	1 37½
5·75	P	17	0·022	34·00	P	17	0·128	1 40
5·60	P	17	0·021	33·90	P	17	0·128	1 42½
5·50	P	17	0·021	33·75	P	17	0·127	1 45
5·25	P	17	0·019	33·60	P	17	0·126	1 47½
5·00	P	17	0·018	33·50	P	17	0·126	1 50
5·00	P	17	0·018	33·30	P	17	0·125	1 52½
4·90	P	16	0·017	33·10	P	16	0·124	1 55
4·75	P	16	0·017	32·90	P	16	0·123	1 57½
4·50	P	16	0·016	32·75	P	16	0·122	2 0
4·50	P	16	0·016	32·60	P	16	0·121	2 2½
4·25	P	15	0·015	32·40	P	15	0·120	2 5
4·10	P	15	0·015	32·20	P	15	0·119	2 7½
4·00	P	15	0·014	32·00	P	15	0·118	2 10
3·90	P	15	0·014	31·90	P	15	0·118	2 12½
3·75	P	15	0·014	31·80	P	15	0·117	2 15
3·60	P	15	0·013	31·60	P	15	0·117	2 17½
3·50	P	14	0·013	31·50	P	14	0·116	2 20
3·40	P	14	0·013	31·20	P	14	0·115	2 22½
3·25	P	14	0·012	30·90	P	14	0·113	2 25
3·10	P	14	0·012	30·60	P	14	0·112	2 27½
3·00	P	14	0·012	30·25	P	14	0·111	2 30
2·75	P	14	0·011	30·10	P	14	0·110	2 32½
2·50	P	13	0·010	30·00	P	13	0·110	2 35
2·50	P	13	0·010	29·90	P	13	0·109	2 37½
2·50	P	13	0·010	29·75	P	13	0·109	2 40
2·40	P	13	0·010	29·50	P	13	0·108	2 42½
2·25	P	13	0·009	29·25	P	13	0·106	2 45
2·10	P	13	0·009	29·00	P	13	0·105	2 47½
2·00	P	13	0·009	28·75	P	13	0·104	2 50
1·90	P	13	0·008	28·50	P	13	0·103	2 52½
1·75	P	13	0·007	28·25	P	13	0·102	2 55
1·70	P	13	0·007	28·00	P	13	0·101	2 57½
1·60	P	13	0·006	27·75	P	13	0·100	3 0
1·00	P	13	0·004	26·80	P	13	0·097	3 10
0·70	P	13	0·003	25·90	P	13	0·093	3 20
0·50	P	13	0·002	25·00	P	13	0·089	3 30
0·30	P	13	0·001	24·00	P	13	0·086	3 40
0·00	Zero	13	0·000	23·00	P	13	0·082	3 50
0·50	N	12	0·002	22·00	P	12	0·079	4 0
0·75	N	12	0·003	21·00	P	12	0·075	4 10
0·90	N	12	0·003	20·00	P	12	0·072	4 20
1·00	N	12	0·004	19·00	P	12	0·068	4 30
1·20	N	12	0·004	18·25	P	12	0·065	4 40
1·30	N	12	0·005	17·50	P	12	0·063	4 50
1·50	N	12	0·006	16·75	P	12	0·060	5 0
1·70	N	12	0·007	16·00	P	12	0·058	5 10
1·80	N	12	0·007	15·00	P	12	0·054	5 20
2·00	N	12	0·009	14·00	P	12	0·051	5 30
2·40	N	12	0·010	13·40	P	12	0·050	5 40
2·60	N	12	0·011	12·80	P	12	0·047	5 50
2·75	N	12	0·011	12·25	P	12	0·045	6 0
Greatest E.M.F. observed, 0·064 of a Volt. Average E.M.F. „ 0·0[illegible] „				Greatest E.M.F. observed, 0·135 of a Volt. Average E.M.F. „ 0·110 „				

TABLE D.—THE ELECTROMOTIVE FORCE, ETC., DURING DIFFUSION OF SEA WATER AND DISTILLED WATER, ACTING ON THE SAME METAL OVER TIDAL PERIODS OF SIX HOURS.

"Soft" Siemens-Martin Steel (bright). (See Fig. 2.)				"Hard" Siemens-Martin Steel (bright). (See Fig. 2.)				
1	2	3	4	1	2	3	4	
Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the "Soft" Siemens-Martin Steel Bar in the Sea WaterCompartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electro-motive Force in Volts.	Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the "Hard" Siemens-Martin Steel Bar in the Sea WaterCompartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electro-motive Force in Volts.	Time from commencement of Experiment.
								H. M.
11·80	P	243	0·059	0·50	P	243	0·003	....
21·00	P	202	0·102	1·75	P	202	0·010	0 2½
24·00	P	192	0·115	9·00	P	192	0·045	0 5
24·00	P	167	0·110	24·00	P	167	0·110	0 7½
23·00	P	148	0·103	28·00	P	148	0·127	0 10
22·50	P	113	0·095	30·00	P	113	0·130	0 12½
22·00	P	102	0·092	30·25	P	102	0·129	0 15
21·50	P	85	0·087	30·75	P	85	0·127	0 17½
21·25	P	76	0·085	30·90	P	76	0·126	0 20
21·00	P	70	0·083	30·90	P	70	0·125	0 22½
20·50	P	64	0·080	30·90	P	64	0·124	0 25
20·00	P	57	0·078	30·90	P	57	0·122	0 27½
19·50	P	51	0·075	30·90	P	51	0·121	0 30
19·00	P	46	0·072	30·90	P	46	0·120	0 32½
18·75	P	42	0·071	30·75	P	42	0·119	0 35
18·50	P	39	0·070	30·25	P	39	0·116	0 37½
18·00	P	36	0·067	30·00	P	36	0·115	0 40
17·50	P	34	0·065	29·50	P	34	0·112	0 42½
17·00	P	32	0·064	29·00	P	32	0·109	0 45
16·50	P	30	0·061	28·75	P	30	0·108	0 47½
16·00	P	29	0·060	28·25	P	29	0·105	0 50
15·50	P	27	0·058	27·75	P	27	0·103	0 52½
15·00	P	26	0·056	27·25	P	26	0·101	0 55
14·50	P	26	0·054	26·90	P	26	0·099	0 57½
14·00	P	25	0·052	26·50	P	25	0·098	1 0
13·75	P	24	0·052	26·00	P	24	0·095	1 2½
13·50	P	23	0·051	25·50	P	23	0·093	1 5
13·25	P	22	0·050	25·00	P	22	0·091	1 7½
13·00	P	21	0·049	24·50	P	21	0·089	1 10
12·60	P	21	0·047	24·00	P	21	0·087	1 12½
12·25	P	20	0·046	23·50	P	20	0·085	1 15
12·00	P	20	0·045	23·00	P	20	0·083	1 17½
11·75	P	19	0·044	22·50	P	19	0·081	1 20
11·50	P	19	0·043	21·90	P	19	0·079	1 22½
11·25	P	18	0·042	21·25	P	18	0·077	1 25
10·90	P	18	0·041	20·90	P	18	0·075	1 27½
10·50	P	17	0·040	20·50	P	17	0·074	1 30
10·25	P	17	0·039	20·25	P	17	0·073	1 32½
10·00	P	17	0·039	20·00	P	17	0·072	1 35
9·75	P	17	0·037	19·60	P	17	0·071	1 37½
9·50	P	17	0·036	19·25	P	17	0·070	1 40
9·25	P	17	0·035	19·00	P	17	0·069	1 42½
9·00	P	17	0·034	18·75	P	17	0·068	1 45
8·75	P	17	0·033	18·40	P	17	0·067	1 47½
8·50	P	17	0·033	18·00	P	17	0·065	1 50
8·25	P	17	0·031	17·60	P	17	0·064	1 52½
8·00	P	16	0·030	17·25	P	16	0·063	1 55
7·90	P	16	0·030	17·10	P	16	0·062	1 57½
7·75	P	16	0·029	16·90	P	16	0·061	2 0
7·60	P	16	0·029	16·60	P	16	0·060	2 2½
7·50	P	15	0·028	16·25	P	15	0·059	2 5
7·25	P	15	0·028	16·10	P	15	0·058	2 7½
7·00	P	15	0·027	15·90	P	15	0·058	2 10
6·90	P	15	0·027	15·60	P	15	0·057	2 12½
6·75	P	15	0·026	15·25	P	15	0·055	2 15
6·60	P	15	0·026	15·10	P	15	0·055	2 17½
6·50	P	14	0·025	14·90	P	14	0·054	2 20
6·25	P	14	0·024	14·70	P	14	0·053	2 22½
6·00	P	14	0·023	14·50	P	14	0·053	2 25
5·75	P	14	0·022	14·20	P	14	0·052	2 27½
5·50	P	14	0·021	14·00	P	14	0·051	2 30
5·40	P	14	0·020	13·70	P	14	0·051	2 32½
5·25	P	13	0·019	13·50	P	13	0·050	2 35
5·10	P	13	0·018	13·30	P	13	0·049	2 37½
5·00	P	13	0·018	13·00	P	13	0·048	2 40
5·00	P	13	0·018	12·80	P	13	0·047	2 42½
4·90	P	13	0·017	12·50	P	13	0·046	2 45
4·80	P	13	0·017	12·25	P	13	0·045	2 47½
4·75	P	13	0·017	12·00	P	13	0·044	2 50
4·60	P	13	0·016	11·50	P	13	0·043	2 52½
4·40	P	13	0·015	11·00	P	13	0·041	2 55
4·20	P	13	0·015	10·75	P	13	0·041	2 57½
4·00	P	13	0·014	10·50	P	13	0·040	3 0
3·75	P	13	0·014	9·90	P	13	0·038	3 10
3·50	P	13	0·013	9·20	P	13	0·034	3 20
3·25	P	13	0·012	8·50	P	13	0·032	3 30
3·00	P	13	0·011	8·00	P	13	0·030	3 40
2·75	P	13	0·011	7·50	P	13	0·028	3 50
2·50	P	12	0·010	7·00	P	12	0·027	4 0
2·40	P	12	0·010	6·40	P	12	0·025	4 10
2·20	P	12	0·009	5·80	P	12	0·022	4 20
2·00	P	12	0·009	5·25	P	12	0·019	4 30
1·70	P	12	0·007	5·00	P	12	0·018	4 40
1·40	P	12	0·005	4·75	P	12	0·017	4 50
1·00	P	12	0·004	4·50	P	12	0·016	5 0
0·80	P	12	0·003	4·30	P	12	0·015	5 10
0·60	P	12	0·002	4·10	P	12	0·014	5 20
0·50	P	12	0·002	4·00	P	12	0·014	5 30
0·30	P	12	0·061	3·80	P	12	0·014	5 40
0·10	P	12	0·000	3·70	P	12	0·013	5 50
0·00	Zero.	12	0·000	3·50	P	12	0·013	6 0
Greatest E.M.F. observed, 0·115 of a Volt. Average E.M.F. „ 0·088 „				Greatest E.M.F. observed, 0·130 of a Volt. Average E.M.F. „ 0·066 „				

TABLE E.—THE ELECTROMOTIVE FORCE, ETC., DURING DIFFUSION OF SEA WATER AND DISTILLED WATER, ACTING ON THE SAME METAL OVER TIDAL PERIODS OF SIX HOURS.

"Soft" Cast Steel (bright). (See Fig. 2.)				"Hard" Cast Steel (bright). (See Fig. 2.)				
1	2	3	4	1	2	3	4	
Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the "Soft" Cast Steel Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electromotive Force in Volts.	Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the "Hard" Cast Steel Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electromotive Force in Volts.	Time from commencement of Experiment.
								H. M.
14·00	P	243	0·073	4·00	P	243	0·020	....
17·75	P	202	0·086	5·00	P	202	0·024	0 2½
25·00	P	192	0·119	8·00	P	192	0·040	0 5
26·00	P	167	0·120	10·50	P	167	0·051	0 7½
26·25	P	148	0·118	13·50	P	148	0·063	0 10
24·50	P	113	0·104	17·50	P	113	0·075	0 12½
22·50	P	102	0·094	19·75	P	102	0·083	0 15
20·50	P	85	0·083	20·90	P	85	0·085	0 17½
19·00	P	76	0·076	21·50	P	76	0·086	0 20
17·50	P	70	0·070	22·00	P	70	0·087	0 22½
16·05	P	64	0·063	22·25	P	64	0·087	0 25
15·25	P	57	0·060	22·50	P	57	0·087	0 27½
14·50	P	51	0·057	22·50	P	51	0·086	0 30
14·00	P	46	0·054	22·50	P	46	0·085	0 32½
13·25	P	42	0·052	22·50	P	42	0·085	0 35
12·45	P	39	0·049	22·25	P	39	0·083	0 37½
12·25	P	36	0·047	22·10	P	36	0·082	0 40
11·75	P	34	0·045	22·00	P	34	0·082	0 42½
11·00	P	32	0·043	21·75	P	32	0·081	0 45
10·25	P	30	0·040	21·25	P	30	0·078	0 47½
10·00	P	29	0·040	21·00	P	29	0·077	0 50
9·60	P	27	0·037	20·90	P	27	0·077	0 52½
9·10	P	26	0·035	20·25	P	26	0·074	0 55
8·75	P	26	0·034	20·00	P	26	0·073	0 57½
8·30	P	25	0·032	19·75	P	25	0·072	1 0
8·00	P	24	0·030	19·50	P	24	0·071	1 2½
7·75	P	23	0·029	19·10	P	23	0·070	1 5
7·40	P	22	0·028	18·90	P	22	0·069	1 7½
7·00	P	21	0·027	18·50	P	21	0·067	1 10
6·75	P	21	0·026	18·25	P	21	0·067	1 12½
6·50	P	20	0·026	18·00	P	20	0·065	1 15
6·40	P	20	0·025	17·50	P	20	0·064	1 17½
6·20	P	19	0·024	17·10	P	19	0·062	1 20
6·00	P	19	0·023	19·80	P	19	0·061	1 22½
5·80	P	18	0·022	16·50	P	18	0·060	1 25
5·60	P	18	0·021	19·25	P	18	0·059	1 27½
5·50	P	17	0·021	16·00	P	17	0·058	1 30
5·40	P	17	0·020	15·70	P	17	0·057	1 32½
5·20	P	17	0·019	15·40	P	17	0·056	1 25
5·00	P	17	0·018	15·10	P	17	0·055	1 37½
4·90	P	17	0·017	14·80	P	17	0·054	1 40
4·75	P	17	0·017	14·50	P	17	0·053	1 42½
4·60	P	17	0·016	14·25	P	17	0·052	1 45
4·50	P	17	0·016	14·00	P	17	0·052	1 47½
4·30	P	17	0·015	13·75	P	17	0·051	1 50
4·10	P	17	0·015	13·50	P	17	0·050	1 52½
4·00	P	16	0·014	13·25	P	16	0·049	1 55
3·90	P	16	0·014	13·00	P	16	0·048	1 57½
3·70	P	16	0·013	12·70	P	16	0·047	2 0
3·60	P	16	0·013	12·40	P	16	0·046	2 2½
3·40	P	15	0·013	12·10	P	15	0·045	2 5
3·20	P	15	0·012	11·80	P	15	0·044	2 7½
3·00	P	15	0·012	11·50	P	15	0·043	2 10
2·90	P	15	0·011	11·25	P	15	0·042	2 12½
2·75	P	15	0·011	11·00	P	15	0·041	2 15
2·60	P	15	0·011	10·75	P	15	0·041	2 17½
2·50	P	14	0·010	10·50	P	14	0·040	2 20
2·40	P	14	0·010	10·25	P	14	0·039	2 22½
2·25	P	14	0·009	10·00	P	14	0·039	2 25
2·10	P	14	0·009	9·90	P	14	0·038	2 27½
2·00	P	14	0·009	9·75	P	14	0·037	2 30
1·90	P	14	0·008	9·50	P	14	0·036	2 32½
1·75	P	13	0·007	9·25	P	13	0·035	2 35
1·60	P	13	0·006	9·00	P	13	0·034	2 37½
1·5[illegible]	P	13	0·006	8·75	P	13	0·033	2 40
1·50	P	13	0·006	8·50	P	13	0·032	2 42½
1·40	P	13	0·005	8·25	P	13	0·031	2 45
1·30	P	13	0·005	8·10	P	13	0·030	2 47½
1·25	P	13	0·005	8·00	P	13	0·030	2 50
1·25	P	13	0·005	7·90	P	13	0·029	2 52½
1·20	P	13	0·004	7·75	P	13	0·029	2 55
1·10	P	13	0·004	7·50	P	13	0·028	2 57½
1·00	P	13	0·004	7·25	P	13	0·027	3 0
0·50	P	13	0·002	6·50	P	13	0·025	3 10
0·00	Zero.	13	0·000	5·00	P	13	0·023	3 20
0·25	N	13	0·001	5·50	P	13	0·020	3 30
0·40	N	13	0·001	4·75	P	13	0·017	3 40
0·60	N	13	0·002	4·00	P	13	0·014	3 50
0·75	N	12	0·003	3·25	P	12	0·012	4 0
0·80	N	12	0·003	3·00	P	12	0·011	4 10
0·90	N	12	0·003	2·75	P	12	0·011	4 20
1·00	N	12	0·004	2·50	P	12	0·010	4 30
1·00	N	12	0·004	2·25	P	12	0·009	4 40
1·00	N	12	0·004	2·00	P	12	0·009	4 50
1·00	N	12	0·004	1·75	P	12	0·007	5 0
1·00	N	12	0·004	1·50	P	12	0·006	5 10
0·90	N	12	0·003	1·25	P	12	0·005	5 20
0·90	N	12	0·003	1·00	P	12	0·004	5 30
0·80	N	12	0·003	0·80	P	12	0·003	5 40
0·60	N	12	0·002	0·60	P	12	0·002	5 50
0·50	N	12	0·002	0·50	P	12	0·002	6 0
Greatest E.M.F. observed, 0·120 of a Volt. *Average E.M.F.* „ 0·026 „				Greatest E.M.F. observed, 0·087 of a Volt. Average E.M.F. „ 0·047 „				

TABLE F.—THE ELECTROMOTIVE FORCE, ETC., DURING DIFFUSION OF SEA WATER AND DISTILLED WATER, ACTING ON THE SAME METAL OVER TIDAL PERIODS OF SIX HOURS.

Best Cast Metal (bright). (No. 1 on Table A of Analyses.) (See Fig. 2.)				Common Cast Metal (bright). (No. 2 on Table A of Analyses.) (See Fig. 2.)				
1	2	3	4	1	2	3	4	
Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the Cast Metal Bar (No. 1) in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electro-motive Force in Volts.	Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the Cast Metal Bar (No. 2) in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electro-motive Force in Volts.	Time from commencement of Experiment. H. M.
0·00	Zero.	243	0·000	0·00	Zero.	243	0·000	...
4·50	P	202	0·021	3·50	P	202	0·017	0 2½
9·00	P	192	0·045	7·00	P	192	0·036	0 5
14·00	P	167	0·066	8·75	P	167	0·042	0 7½
16·75	P	148	0·076	9·25	P	148	0·043	0 10
17·25	P	113	0·074	9·10	P	113	0·040	0 12½
17·10	P	102	0·072	8·50	P	102	0·038	0 15
16·90	P	85	0·069	8·00	P	85	0·034	0 17½
16·75	P	76	0·068	7·50	P	76	0·031	0 20
16·25	P	70	0·065	7·00	P	70	0·030	0 22½
15·75	P	64	0·062	6·50	P	64	0·028	0 25
15·25	P	57	0·060	6·25	P	57	0·026	0 27½
15·00	P	51	0·058	6·00	P	51	0·025	0 30
14·60	P	46	0·056	5·60	P	46	0·022	0 32½
14·00	P	42	0·054	5·30	P	42	0·020	0 35
13·60	P	39	0·053	5·10	P	39	0·019	0 37½
13·10	P	36	0·050	4·90	P	36	0·018	0 40
12·75	P	34	0·049	4·60	P	34	0·017	0 42½
12·25	P	32	0·047	4·40	P	32	0·016	0 45
12·00	P	30	0·046	4·20	P	30	0·015	0 47½
11·75	P	29	0·045	4·00	P	29	0·015	0 50
11·25	P	27	0·043	3·80	P	27	0·014	0 52½
10·90	P	26	0·042	3·60	P	26	0·013	0 55
10·75	P	26	0·042	3·50	P	26	0·013	0 57½
10·25	P	25	0·040	3·40	P	25	0·013	1 0
10·00	P	24	0·039	3·25	P	24	0·012	1 2½
9·80	P	23	0·038	3·10	P	23	0·012	1 5
9·60	P	22	0·037	3·00	P	22	0·012	1 7½
9·40	P	21	0·036	2·90	P	21	0·011	1 10
9·20	P	21	0·035	2·75	P	21	0·011	1 12½
9·00	P	20	0·034	2·60	P	20	0·011	1 15
8·90	P	20	0·034	2·50	P	20	0·010	1 17½
8·80	P	19	0·033	2·40	P	19	0·010	1 20
8·60	P	19	0·033	2·25	P	19	0·010	1 22½
8·50	P	18	0·033	2·10	P	18	0·009	1 25
8·25	P	18	0·031	2·00	P	18	0·009	1 27½
8·00	P	17	0·030	1·90	P	17	0·008	1 30
7·80	P	17	0·029	1·75	P	17	0·007	1 32½
7·60	P	17	0·029	1·60	P	17	0·006	1 35
7·40	P	17	0·028	1·60	P	17	0·006	1 37½
7·20	P	17	0·027	1·50	P	17	0·006	1 40
7·00	P	17	0·027	1·50	P	17	0·006	1 42½
6·90	P	17	0·027	1·40	P	17	0·005	1 45
6·60	P	17	0·026	1·30	P	17	0·005	1 47½
6·25	P	17	0·024	1·25	P	17	0·005	1 50
6·10	P	17	0·024	1·20	P	17	0·004	1 52½
6·00	P	16	0·023	1·10	P	16	0·004	1 55
5·90	P	16	0·023	1·00	P	16	0·004	1 57½
5·75	P	16	0·022	0·96	P	16	0·003	2 0
5·50	P	16	0·021	0·90	P	16	0·003	2 2½
5·25	P	15	0·019	0·90	P	15	0·003	2 5
5·10	P	15	0·018	0·90	P	15	0·003	2 7½
5·00	P	15	0·018	0·90	P	15	0·003	2 10
4·80	P	15	0·017	0·90	P	15	0·003	2 12½
4·70	P	15	0·016	0·80	P	15	0·003	2 15
4·60	P	15	0·016	0·80	P	15	0·003	2 17½
4·50	P	14	0·016	0·75	P	14	0·003	2 20
4·40	P	14	0·015	0·70	P	14	0·003	2 22½
4·25	P	14	0·015	0·60	P	14	0·002	2 25
4·10	P	14	0·015	0·60	P	14	0·002	2 27½
4·00	P	14	0·014	0·50	P	14	0·002	2 30
3·90	P	14	0·014	0·50	P	14	0·002	2 32½
3·70	P	13	0·013	0·50	P	13	0·002	2 35
3·60	P	13	0·013	0·40	P	13	0·001	2 37½
3·50	P	13	0·013	0·40	P	13	0·001	2 40
3·40	P	13	0·013	0·40	P	13	0·001	2 42½
3·25	P	13	0·012	0·40	P	13	0·001	2 45
3·10	P	13	0·012	0·30	P	13	0·001	2 47½
3·00	P	13	0·011	0·30	P	13	0·001	2 50
2·80	P	13	0·011	0·30	P	13	0·001	2 52½
2·60	P	13	0·010	0·25	P	13	0·001	2 55
2·40	P	13	0·010	0·25	P	13	0·001	2 57½
2·30	P	13	0·010	0·20	P	13	0·001	3 0
2·00	P	13	0·009	0·00	Zero.	13	0·000	3 10
1·60	P	13	0·006	0·10	N	13	0·001	3 20
1·25	P	13	0·005	0·20	N	13	0·001	3 30
1·10	P	13	0·004	0·20	N	13	0·001	3 40
1·00	P	13	0·004	0·25	N	13	0·001	3 50
0·90	P	12	0·003	0·25	N	12	0·001	4 0
0·60	P	12	0·002	0·40	N	12	0·001	4 10
0·30	P	12	0·001	0·50	N	12	0·002	4 20
0·00	Zero.	12	0·000	0·60	N	12	0·002	4 30
0·20	N	12	0·001	0·60	N	12	0·002	4 40
0·40	N	12	0·001	0·70	N	12	0·003	4 50
0·50	N	12	0·002	0·75	N	12	0·003	5 0
0·60	N	12	0·002	0·60	N	12	0·002	5 10
0·80	N	12	0·003	0·50	N	12	0·002	5 20
1·00	N	12	0·004	0·40	N	12	0·001	5 30
1·00	N	12	0·004	0·30	N	12	0·001	5 40
1·00	N	12	0·004	0·20	N	12	0·001	5 50
1·00	N	12	0·004	0·10	N	12	0·000	6 0
Greatest E.M.F. observed, *0·076 of a Volt.* Average E.M.F. " *0·027* "				Greatest E.M.F. observed, 0·043 of a Volt. Average E.M.F. " 0·009 "				

TABLE G.—THE ELECTROMOTIVE FORCE, ETC., DURING DIFFUSION OF SEA WATER AND DISTILLED WATER, ACTING ON THE SAME METAL OVER TIDAL PERIODS OF SIX HOURS.

Best Cast Metal (in the rough). (No. 1 on Table A of Analyses.) (See Fig. 2.)				Wrought Iron (covered with its own blue magnetic oxide). (See Fig. 2.)				
1	2	3	4	1	2	3	4	
Deflection of Galvanometer in Degrees at intrevals of time as stated.	Electro-Chemical position of the Cast Metal Bar (No. 1) in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electro-motive Force in Volts.	Deflection of Galvanometer in Degrees at intervals of time as stated.	Electro-Chemical position of the Wrought Iron Bar in the Sea Water Compartment.	Time Changes of Resistance in the Cells (see Fig. 4) in Ohms.	Electro-motive Force in Volts.	Time from commencement of Experiment.
								H. M.
14·50	P	243	0·076	11·00	N	243	0·059	....
15·50	P	202	0·075	10·75	N	202	0·055	0 2½
15·00	P	192	0·073	10·50	N	192	0·053	0 5
14·50	P	167	0·068	10·25	N	167	0·050	0 7½
14·00	P	148	0·064	10·00	N	148	0·048	0 10
13·25	P	113	0·058	9·75	N	113	0·044	0 12½
12·90	P	102	0·055	9·75	N	102	0·043	0 15
12·50	P	85	0·052	9·60	N	85	0·041	0 17½
12·25	P	76	0·050	9·50	N	76	0·040	0 20
12·00	P	70	0·049	9·50	N	70	0·040	0 22½
11·75	P	64	0·048	9·50	N	64	0·039	0 25
11·50	P	57	0·046	9·50	N	57	0·039	0 27½
11·25	P	51	0·045	9·50	N	51	0·038	0 30
11·10	P	46	0·044	9·50	N	46	0·038	0 32½
11·00	P	42	0·044	9·50	N	42	0·038	0 35
11·00	P	39	0·043	9·40	N	39	0·037	0 37½
10·90	P	36	0·043	9·25	N	36	0·036	0 40
10·75	P	34	0·042	9·20	N	34	0·036	0 42½
10·60	P	32	0·042	9·10	N	32	0·035	0 45
10·50	P	30	0·041	9·10	N	30	0·035	0 47½
10·25	P	29	0·040	9·00	N	29	0·035	0 50
10·10	P	27	0·040	9·00	N	27	0·034	0 52½
10·00	P	26	0·039	8·90	N	26	0·034	0 55
10·00	P	26	0·039	8·80	N	26	0·034	0 57½
10·00	P	25	0·039	8·75	N	25	0·034	1 0
9·90	P	24	0·039	8·50	N	24	0·033	1 2½
9·75	P	23	0·038	8·25	N	23	0·032	1 5
9·60	P	22	0·037	8·25	N	22	0·032	1 7½
9·50	P	21	0·036	8·25	N	21	0·031	1 10
9·50	P	21	0·036	8·20	N	21	0·031	1 12½
9·40	P	20	0·036	8·10	N	20	0·031	1 15
9·30	P	20	0·035	8·10	N	20	0·031	1 17½
9·25	P	19	0·035	8·00	N	19	0·030	1 20
9·10	P	19	0·034	7·90	N	19	0·030	1 22½
9·00	P	18	0·034	7·75	N	18	0·029	1 25
9·00	P	18	0·034	7·60	N	18	0·029	1 27½
9·00	P	17	0·034	7·50	N	17	0·028	1 30
8·80	P	17	0·033	7·40	N	17	0·028	1 32½
8·75	P	17	0·033	7·25	N	17	0·028	1 35
8·70	P	17	0·033	7·20	N	17	0·027	1 37½
8·60	P	17	0·033	7·10	N	17	0·027	1 40
8·60	P	17	0·033	7·10	N	17	0·027	1 42½
8·50	P	17	0·033	7·00	N	17	0·027	1 45
8·50	P	17	0·033	7·00	N	17	0·027	1 47½
8·40	P	17	0·032	7·00	N	17	0·027	1 50
8·30	P	17	0·031	7·00	N	17	0·027	1 52½
8·25	P	16	0·031	6·90	N	16	0·027	1 55
8·20	P	16	0·031	6·90	N	16	0·027	1 57½
8·10	P	16	0·030	6·80	N	16	0·026	2 0
8·10	P	16	0·030	6·80	N	16	0·026	2 2½
8·00	P	15	0·030	6·75	N	15	0·026	2 5
8·00	P	15	0·030	6·60	N	15	0·026	2 7½
8·00	P	15	0·030	6·50	N	15	0·026	2 10
8·00	P	15	0·030	6·50	N	15	0·026	2 12½
7·90	P	15	0·030	6·40	N	15	0·025	2 15
7·80	P	15	0·029	6·30	N	15	0·025	2 17½
7·75	P	14	0·029	6·25	N	14	0·024	2 20
7·75	P	14	0·029	6·25	N	14	0·024	2 22½
7·75	P	14	0·029	6·20	N	14	0·024	2 25
7·70	P	14	0·029	6·10	N	14	0·024	2 27½
7·60	P	14	0·029	6·00	N	14	0·023	2 30
7·60	P	14	0·029	6·00	N	14	0·023	2 32½
7·60	P	13	0·028	5·90	N	13	0·023	2 35
7·50	P	13	0·028	5·80	N	13	0·022	2 37½
7·50	P	13	0·028	5·75	N	13	0·022	2 40
7·50	P	13	0·028	5·75	N	13	0·022	2 42½
7·50	P	13	0·028	5·70	N	13	0·021	2 45
7·40	P	13	0·028	5·70	N	13	0·021	2 47½
7·25	P	13	0·027	5·60	N	13	0·021	2 50
7·25	P	13	0·027	5·60	N	13	0·021	2 52½
7·25	P	13	0·027	5·60	N	13	0·021	2 55
7·20	P	13	0·027	5·50	N	13	0·020	2 57½
7·10	P	13	0·027	5·50	N	13	0·020	3 0
7·00	P	13	0·027	5·30	N	13	0·019	3 10
6·80	P	13	0·026	5·10	N	13	0·018	3 20
6·60	P	13	0·026	4·90	N	13	0·017	3 30
6·40	P	13	0·025	4·90	N	13	0·017	3 40
6·20	P	13	0·024	5·00	N	13	0·018	3 50
6·00	P	12	0·023	5·00	N	12	0·018	4 0
5·90	P	12	0·022	5·00	N	12	0·018	4 10
5·80	P	12	0·022	5·00	N	12	0·018	4 20
5·75	P	12	0·022	5·00	N	12	0·018	4 30
5·60	P	12	0·021	5·00	N	12	0·018	4 40
5·40	P	12	0·020	4·90	N	12	0·017	4 50
5·25	P	12	0·019	4·90	N	12	0·017	5 0
5·20	P	12	0·019	4·90	N	12	0·017	5 10
5·10	P	12	0·018	4·80	N	12	0·017	5 20
5·10	P	12	0·018	4·80	N	12	0·017	5 30
5·10	P	12	0·018	4·80	N	12	0·017	5 40
5·00	P	12	0·018	4·75	N	12	0·017	5 50
5·00	P	12	0·018	4·75	N	12	0·017	6 0
Greatest E.M.F. observed, 0·076 of a Volt. *Average E.M.F.* " 0·035 "				Greatest E.M.F. observed, 0·059 of a Volt. Average E.M.F. " 0·028 "				

The experiments for the electromotive force in the previous tables were carefully repeated (using another galvanometer). For the second set of observations, the bars were also re-turned ($\frac{1}{32}$ inch taken off), and the results were generally confirmatory, but with some variations, possibly accounted for by the somewhat different molecular structure or composition presented by the new surface of the metals exposed.

From an examination of the results recorded in the tables, it will be seen in what comparative manner the metals arranged themselves, taking as a guide in each case the average electromotive force during the whole tidal period of six hours.

TABLE H.

	Percentage of Combined Carbon.	Average Electromotive Force in Volts.	Highest Electromotive Force in Volts.
Cast metal (No. 2) (bright)	0·670	0·009	0·043
Wrought iron hammered bars (bright)	...	0·017	0·036
"Soft" Bessemer steel (do.)	0·150	0·024	0·064
"Soft" cast steel (do.)	0·450	0·026	0·120
Cast metal (No. 1) (do.)	0·390	0·027	0·076
Wrought iron (covered with its own blue magnetic oxide)	none.	0·028	0·059
Cast metal (No. 1) (in the rough)	0·390	0·035	0·076
"Soft" Siemens-Martin steel (bright)	0·230	0·038	0·115
"Hard" cast steel (do.)	0·190	0·047	0·087
Wrought iron rolled bars (do.)	none.	0·054	0·095
"Hard" Siemens-Martin steel (do.)	0·460	0·066	0·130
"Hard" Bessemer steel (do.)	0·480	0·110	0·135

Referring now to the Tables B, C, D, E, F, and G of the electromotive force, etc., theoretically, the electromotive force should be greatest at the commencement and gradually reduce. The results obtained do not, however, show this, as the full electromotive force recorded by the galvanometer was not manifest for some minutes.

The author considers that the first few results recorded in each of the tables do not, therefore, fully represent the extent of the electromotive force at the commencement. The low deflection of the galvanometer at first is accounted for by the large resistance in the cells during the first few minutes (Fig. 2). This probably prevents the full electromotive force from being at first realised; the matter, however, appears shortly to rectify itself. A short time also possibly elapses before the chemical action fully commences on the components of the metals.

Experiments confirmatory of this were made by the first fling method, a Daniell's cell being in circuit, and by alternating the direction of the current sent through the cells (Fig. 2).

A circumstance of interest in connection with these experiments is the change of electro-chemical position which not unfrequently happened, as will be seen on reference to the tables.

Another noticeable feature was the electro-chemical position maintained by the wrought iron bar (covered with its blue magnetic oxide) immersed in the sea water, this bar being in the negative position throughout. Repeated experiments confirmed this.

Also when the bars were removed from the solutions at the close of an experiment, the different manner in which the metals had been acted upon in the respective cells was decidedly noticeable.

In all cases the oxidation of the metals in the distilled water presented a peculiar appearance, showing long, needle-shaped streaks of oxides in the line of the axes of the bars, the bars in the sea water compartment remaining almost bright.

From an examination of the results recorded in the tables and curves (taking the highest and the average electromotive force) it will be seen in what comparative manner the metals arranged themselves under the conditions of the experiment. Twelve accurate curves of the electromotive force (each the result of 91 observations) were obtained, showing the effect of this tidal action on the various groups of metals under observation. The general contour and character of these affords interesting information respecting such action on the different metals employed.

In every instance the greatest electromotive force was observed from the tidal action on the "hard" steels.

The "soft" steels afforded on the average less electromotive force than the rolled wrought iron, but this group of steels generally gave a higher electromotive force near the commencement of each experiment.

The rolled wrought iron gave more electromotive force than the hammered wrought iron, which latter, together with the cast metal No. 2, gave the least electromotive force in these observations.

The preceding results and curves, etc., give a quantitative measurement of the electromotive force under the conditions stated, and hence afford an indication of the extent of similar action on structural ironwork in tidal rivers during diffusion between the surface and lower waters, the electromotive force observed being not only appreciable but in many instances very considerable, reaching not unfrequently *the one-tenth to the one-seventh of a volt.*

This destructive action would appear to be exerted most extensively on the lower portion of iron or steel vessels, metallic structures, etc., because such portion is shown by this research to be in the electro-positive position during certain conditions of a tidal stream.

It should be pointed out that similar conditions of galvanic action obtain in all our iron structures in tidal estuaries or rivers, the action of the salt and fresh water in course of diffusion constituting a source of galvanic disintegration independent of any difference in composition of the metals.

It should also be observed that in circumstances where the electromotive force arising from causes here pointed out acts in concert with any electromotive force, from differences of composition of the metals employed in structures, a very considerable total electrolytic disintegration is likely to ensue.

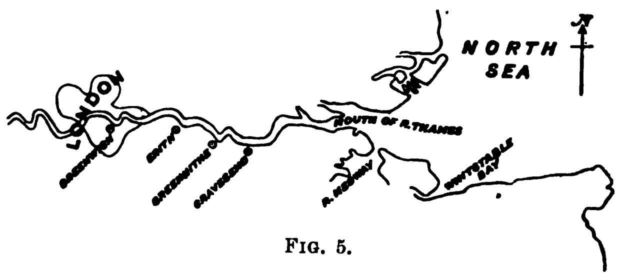


FIG. 5.

From data kindly furnished to the author by Dr. H. Clifton Sorby, F.R.S., an indication is afforded of the nature of the changing composition of the waters of tidal estuaries at various places and depths, a condition, judging from the preceding experiments by the author, quite capable of developing a very considerable amount of electromotive force, and consequent increased corrosive destruction in exposed metallic work of any kind.

It will, however, be sufficient for illustrating the basis and nature of the present investigation to give on Table I. one or two examples showing the great difference

in amount of saline constituents in tidal parts of a river like the Thames, and this difference is doubtless frequently very much greater. Further reference may be also made to a paper by Mr. Birch, M. Inst. C.E., "On the Passage of Upland-Water through a Tidal Estuary" (*Minutes, Proc. Inst. C.E.*, Vol. LXXVIII., page 212), and to the recent very interesting researches "On the Salinity of the Firth of Forth," by Mr. Hugh Robert Mill, B.Sc., F.L.S. (*Proceedings of the Royal Society of Edinburgh*, No. 119, page 29), and "On the Salinity of the Tay Estuary and of St. Andrew's Bay" (read before the R.S.E., July 20, 1885), by the same author.

TABLE I.

Depth from Surface.	Tide.	Chloride of Sodium in Water. Grains per Gallon.	Depth from Surface.	Tide.	Chloride of Sodium in Water. Grains per Gallon.
THAMES WATER—LONDON BRIDGE.					
Surface ...	1 hour flood ...	1·98			
Middle ...	" " ...	3·46			
Surface ...	½ hour ebb ...	2·36			
Middle ...	" " ...	2·72			
Bottom ...	" " ...	2·44			
THAMES WATER—GREENWICH.			**THAMES WATER—CROSSNESS.**		
Surface ...	2 hours' flood	2·39	Surface ...	4 hours' flood	91·95
Middle ...	" "	2·47	20 ft. 0 ins.	" "	109·50
27 ft. 0 ins.	" "	2·80	40 ft. 0 ins.	" "	117·46
Surface ...	2 hours' ebb...	3·95	Surface ...	½ hour ebb ...	104·48
13 ft. 6 ins.	" "	3·89	17 ft. 6 ins.	" "	110·16
27 ft. 0 ins.	" "	4·14	35 ft. 0 ins.	" "	213·70
Surface ...	3 hours' ebb...	3·05	Surface ...	1½ hours' ebb	101·43
11 ft. 0 ins.	" "	4·86	17 ft. 0 ins.	" "	130·35
22 ft. 0 ins.	" "	2·93	34 ft. 0 ins.	" "	189·18
THAMES WATER—ERITH.			**THAMES WATER—GREENHITHE.**		
Top ...	4 hours' flood	238·61	Surface ...	High water ...	755·89
Middle ...	" "	329·25	28 ft. 0 ins.	" "	778·46
Bottom ...	" "	457·12	54 ft. 0 ins.	" "	896·29
			Surface ...	6 hours' ebb...	231·20
			20 ft. 0 ins.	" "	253·77
			39 ft. 0 ins	" "	377·86
THAMES WATER—GRAVESEND.			**THAMES WATER—YANLET CREEK.**		
Surface ...	3 hours' flood	688·82	Surface ...	4 hours' flood	1692·38
30 ft. 0 ins.	" "	901·39	21 ft. 0 ins.	" "	1834·10
61 ft. 0 ins.	" "	992·03	44 ft. 0 ins.	" "	1862·11
Surface ...	1½ hours' ebb	856·90	Surface ...	3 hours' ebb...	1611·63
34 ft. 0 ins.	" "	1170·00	19 ft. 6 ins.	" "	1651·18
			37 ft. 0 ins.	" "	1834·10
Surface ...	6½ hours' ebb	594·87			
30 ft. 0 ins.	" "	686·34			
61 ft. 0 ins.	" "	828·39			

SUGGESTIONS FOR PRACTICAL APPLICATION.

In some instances it will be noticed that the difference in the proportion of chlorides varies to a very considerable extent, the variation being sometimes nearly 100 per cent. between the surface and bottom of the stream; this indicates the state of the saline diffusion and consequent difference of potential. This difference also may frequently be either much greater or less owing to tidal fluctuations.

The tables of electromotive force, etc., contained in the present memoir, together with the diffusion resistance curve (Fig. 4), afford some index of the changing electromotive force arising from such tidal difference of potential.

In the practical application of these data, due allowance should be made for variations in the percentage proportion of salts present in the top and bottom waters.

As an illustration, the Thames at Gravesend (three hours' flood) may be taken. In this instance the chlorides at top were 418 grains and at bottom 602 grains per gallon, whereas the chlorides in fresh water would be about, say 1 grain per gallon.

From these figures it may be inferred that diffusion between the salt and fresh water there and in that particular state of tide was about two-thirds accomplished.

On referring to the resistance curve, Table C, and selecting the resistance answering to a similar state of diffusion, about two-thirds accomplished, say 85 ohms, the corresponding electromotive force is found in the case of say the "soft" Bessemer steel to be 0·057 of a volt, and a similar reference to the other metals would give an indication of the comparative effect.

The state of diffusion (as ascertained from the proportion of chlorides present in top and bottom waters) being known at any place in a tidal stream, then an application of the above method affords an approximate indication of the relative destructive tidal action on the metals under such conditions, assuming that they are acted on relatively in a similar manner, though proportionately to a less extent, in presence of a reduced percentage of salts in the tidal waters. As, however, results are liable to vary with the nature and composition of the metals, it would be preferable to make the tests direct on any metal desired to be examined in a similar manner to that described in course of this paper.

In approaching the subject in the manner stated in this memoir, the author trusts he has been able to afford some indication of the extent of the electromotive force from the action of tidal streams on the various metals experimented upon.

A subject, however, of such interest and importance commends itself for further investigation and research.

NOTE.

For information on the corrosive action of sea water on metals, reference may be made to the following recent papers:—

"Corrosive Effects of Steel on Iron in Salt Water," by Mr. G. Farquharson, read at Institute of Naval Architects, March 30th, 1882.

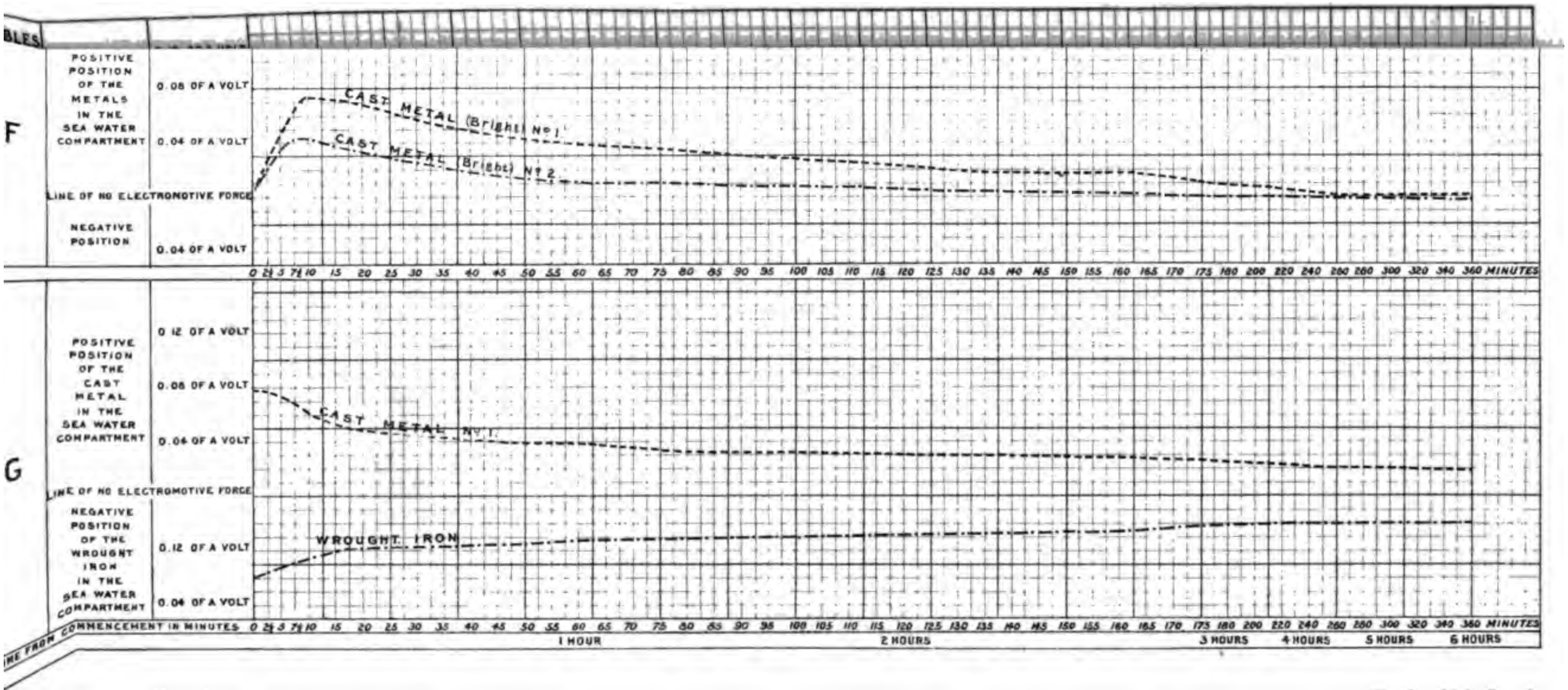
"The relative Electro-Chemical Positions of Wrought Iron, Steels, Cast Metal, etc., in Sea Water and other solutions," by Mr. Thos. Andrews, *Trans. Royal Society of Edinburgh*, Vol. XXXII., Part 1.

"Galvanic Action between Wrought Iron, Cast Metals, and Steels during long exposure in Sea Water, Part I.," by Mr. Thos. Andrews, *Minutes, Proc. Inst. C.E.*, Vol. LXXVII., Session 1883-84, Part III.

"Corrosion of Metals during long exposure in Sea Water, Part II.," by Mr. Thos. Andrews, *Minutes, Proc. Inst. C.E.*, Vol. LXXXII., 1885, Part IV.

"Apparent Lines of Force on passing a Current through Water," *Proceedings, Royal Society of Edin.*, 1884-85.

CURVES OF THE ELECTROMOTIVE FORCE, CONSTRUCTED FROM TABLES B. C. D. E. F. AND G.



Federated Institution of Mining Engineers
Proceedings 1889-90

Andw Reid Sons & Co. Lithos. Newcastle

The PRESIDENT—I am sure we are all very much obliged to Mr. Andrews for the very interesting paper that he has just read to us. I think it is a compliment to this Institute that a paper containing such an enormous amount of scientific research, and containing such an amount of valuable information, should have been brought before us. I fear that some of Mr. Andrews' figures and formulæ may be perhaps thrown away upon members like myself, who have not the intimate knowledge of iron and steel that he has, but this I have been able to grasp fully, and that is how corrosion in iron and steel is caused when brought in contact with tidal streams. It is something to know that this corrosion is caused by an electric current set up by the water in which the column or pillar is the conductor. And this is a matter, it appears to me, of enormous importance, not only where iron bridges and ironwork of all sorts should be put down in tidal waters, but also furnishes great food for thought as to whether the corrosion due to the waters generally found in coal mines may not be the result of some similar action. The use of colliery water is nearly always attended with an enormous amount of corrosion in pipes and boilers, and it would be interesting to know whether any similar action to that we have just heard described may not be the cause of the difficulties we have to contend with. I do not know that I can say any more, except to move that the very best thanks be given to Mr. Andrews for the very able paper that he has read.

Mr. EMERSON BAINBRIDGE—I have much pleasure in seconding the vote of thanks to Mr. Andrews, and feel that we are much honoured as an Institute in having from so great an author as Mr. Andrews a paper of this class. One naturally turns to see in what manner a paper of this sort can reflect upon mining engineering and the mechanical engineering with which we have to do. In addition to the points mentioned by the President, it has occurred to me that the action the paper describes may have a very important bearing on the action of water in steam boilers. I believe that one branch of engineering in which we are a long way behind is the science of treating the many classes of water we have to deal with in colliery operations. Some give us endless trouble and cause great expense and damage to boilers, and it is probable that in feeding boilers something of this sort goes on. Boiling the water produces a certain quantity of salt in the water, in a more or less concentrated form. When the boiler holding the salt water is filled with fresh water there is probably a similar kind of action to that described by Mr. Andrews. If he has investigated that question he may be able to favour us with some very interesting records, which will apply in an important degree to the work we have in hand. I have had a special case lately of corrosion in a boiler in which we discovered that a certain quantity of salt accumulated in various parts of the boiler. We believe that if we blow off the scum we shall much reduce the quantity of corrosion. We need to look more closely to the action of water in boilers. We are apt to blindly deal with boiler compositions, which contain 95 per cent. of water. With regard to boiler insurance, it might be desirable to form a Yorkshire Boiler Insurance Company, coupling with this a laboratory, in which to analyse the water which is used for boiler purposes, dealing with it under the direction of a skilled chemist. In this way we might do a great deal in meeting the important questions, both of the incrustation of boilers, and the quantity of corrosion that takes place in using bad water.

Mr. A. M. CHAMBERS—I have the greatest pleasure in supporting the resolution. I do so all the more because I think the paper shows to us—what, no doubt, all are aware of, but which has been in the past but too little regarded in colliery operations and other operations of manufacturing development—that the patient recording of facts, and of the results of carefully considered experiments, is really a thing to which we ought to give more attention than we have done. The day

It is evident that this system requires great care on the part of the engineman not to allow the rope to be slack; if it were so, the sudden drop would subject the rope to serious strains. There is, however, a clear advantage in this system where scroll drums are in use, as the changing at top and bottom becomes automatic and independent of the engineman, and under all circumstances there is an appreciable saving of time. There is, however, more wear and tear of the cages which fall upon the props with more violence than with the old system.

In January, 1889, the makers of this gear, under patentee in Belgium, offered to supply for a Durham Colliery a complete set of the props to work cages 8 feet long, 3 feet 5 inches wide; cage, 25 cwts.; load and coal, 28 cwts. (load proposed to be worked with two decks), at a cost of 1,500 francs or £62 10s., delivered in Sunderland. To this cost would be added the cost of longer chains than ordinary to the cages required for working at balance platform at pit bottom, also fixing and other expenses. The weight of gear supplied to be about 1,200 kilos or 24 cwts.

The question of nicety in length of ropes, apparently a difficulty, is solved by the use of a balance platform at the pit bottom, a tracing of which accompanies these notes as in operation at the Bascoup Colliery on the writer's visit. This platform arrangement is worked by Mr. Garforth at the Altofts Colliery, Normanton, of which he was good enough to offer inspection, and said it permitted a largely increased get of coals to be drawn compared with the ordinary system, where movements of cages at bank govern movements below. At this colliery, working with ordinary props at bank, the deck which they first discharge is the top deck of cage and lifting for each successive deck, each discharge necessitating a lifting and a settlement on the props. The action of Stauss props at bank would be the reverse of this, and would suggest a clear benefit in time, engine work, and wear of rope.

The question as to how the lever handle to move the props behaves with the weight of cage on the Stauss props, or tacquets, is answered partly in the note of M. Demeurre to the School of Mines of Liége, and was evidenced on inspection of the apparatus in full work by the members of the North of England Institute on their visit to the collieries of Bascoup and Mariemont last autumn, when the precision and rapidity of movement in discharging cages of four decks was much admired; the work at bank being done entirely by young girls in discharge and recharge of cages.

As to the general opinion on the working of this Stauss system of cage props, or tacquets, after some three years' use, the writer has pleasure in thanking M. Julien Weiler, the Manager, and the Directors of the Mariemont Collieries for the facility for inspection they so kindly gave, and also for their letter of December 16th, 1889, in reply to some of the points raised in anticipation, and which I have now pleasure to submit along with these notes for your consideration :

Société Anonyme des Charbonnages de Mariemont, Belgium,
16th December, 1889.

M. Edmund B. Clarke,
Sheffield.

In reply to the letter of 21 Nov., which you have addressed to M. Weiler, our engineer, we have the honour of giving you the following information upon the application of the Stauss tacquets:—

At all our pits we have adopted balanced platforms for loading at the pit bottoms. The operations below and at the surface are independent of each other.

The balances were introduced before the application of the Stauss props, and, therefore, these do not alter in the least the working below.

If the weight of the rope freely suspended in the pit when the cage is below does not suffice to hold the weight of the cage at the surface, the engineman admits a little steam, and he soon acquires the knack of regulating this.

We have cages of 2, 3, and 4 decks, and we do not find that the ropes suffer from shocks when the props are withdrawn.

The length of chains of our cages vary from 0·830 m. to 6·000 m., according to the length that is required for clearing the decks of cages.

The application of the Stauss props was made to gain time at all our pits. Not having preserved accurate data we are unable to give you the exact saving in time.

Accept, etc.,

(Signed) GEORGES DAROGUE,

Assistant Director.

DISCUSSION ON MR. BERTRAM'S AND MR. COBBOLD'S PAPERS ON "OVERWINDING AND ITS PREVENTION."

The PRESIDENT—The next business is the discussion of Mr. Bertram's paper on "Overwinding and its Prevention." I do not know whether all the members here have had the same opportunity that I have perhaps of thoroughly studying the arrangement for preventing overwinding brought before us by Mr. Bertram. I have had a model for some months and have had time to thoroughly study the arrangement, which certainly is a very ingenious one. I do not see any difficulty in applying it. Mr. Bertram seems to have arrived at a means of preventing the carelessness of the engineman doing irretrievable damage. The arrangement acts as a cut-off in the event of the load getting beyond a certain rate of progression in the pit, and it also acts as a means of preventing overwinding by shutting off steam in case of the cage creeping slowly up to the top. There are two arrangements—one to cut off before the cage reaches the pulley, the other to cut off when the engine gets beyond a certain rate of progression. Mr. Bertram's apparatus follows very much on the lines Mr. Cobbold introduced to us, but applied in a somewhat different way. Both are practical methods of preventing overwinding, and both worthy the attention and investigation of members. It is almost impossible to separate these two papers, both being on the same subject, and members have had the opportunity of seeing both Mr. Bertram's and Mr. Cobbold's models at Barnsley and Leeds. I should also like to thank Mr. Cobbold in the name of the Institute, not only for taking the model about, but for circulating descriptions of his apparatus.

Mr. WALLACE—With regard to Mr. Bertram, he purposes sending the machine at his own risk if someone would like to test it and then call a meeting. He will fix the machine free of cost and take it back if it is not satisfactory.

The PRESIDENT—There is one fixed at the Wigan Coal and Iron Company's pit?

Mr. WALLACE—Yes; it has been there eighteen months. I think the two patentees want to put their heads together and talk the matter over; it might lead to some arrangement.

Mr. COBBOLD—I think that would be a good thing indeed. Had it been known that Mr. Bertram had an apparatus this one would not have gone so far as it has done. I was much pleased with Mr. Bertram's. I think it is rather more complicated than my own and Mr. Wood's. This was brought out simply and solely because of recent accidents that have happened in this district. Some means were sought so that no mining engineer of the district could have any excuse that there was no such machine

as would stop his engine automatically. Then, much to my astonishment, at the same meeting, Mr. Bertram's paper was read. If the two apparatuses could be amalgamated, and a part of one put on the other one, a far more perfect machine would be the result. I should be glad to lend Mr. Bertram any assistance that I can in meeting him, and in trying to arrange some combination of apparatus that would be within the reach of every colliery manager who feels that as long as his engine is not provided with an automatic means of shutting off he ought to have one, so that he may be quite sure that the engine is a perfectly safe machine, whether the engineman is lacking in attention or is ignorant, and that it will be impossible for anybody to be overwound, to be dropped down the pit too fast, or to be brought over the pulleys at the top.

The PRESIDENT—Then we must consider the discussion on these two arrangements closed.

DISCUSSION ON MR. LUPTON'S PAPER ON "THE MEDIUM FAN."

The PRESIDENT—A paper was read by Mr. Lupton at the last meeting on "The Medium Fan," and as we have now the particulars of that paper before us we can discuss it. I have read it through carefully since it was published, and do not know that I have anything to add to the remarks I made when the paper was read. Mr. Lupton's figures and deductions are so remarkable altogether that they form an entirely new departure. To be able to give a higher useful effect from a fan than you have initially in the engine you have to drive it is a proposition so absurd that I fear it discounts, to a considerable extent, other facts and figures that were placed before us. So far as the fan itself goes there is nothing very novel in the design, and I shall be very glad if some gentleman will give us his opinion of the fan and paper so that we can discuss it.

Mr. GERRARD—Would it not be as well to wait until Mr. Lupton is here?

The PRESIDENT—Well, we will adjourn the discussion until he can be present if that is your pleasure, gentlemen, and I think it would be as well to do so, as Mr. Lupton may possibly throw a different light on some points that now puzzle us.

The discussion was accordingly adjourned.

DISCUSSION ON MR. R. RUSSELL'S PAPER ON "THE GEOLOGY OF THE SOUTHERN PORTION OF THE YORKSHIRE COAL-FIELD."

The PRESIDENT—The next business on the Agenda is the discussion on Mr. Russell's paper on "The Geology of the Southern portion of the Yorkshire Coal-field." I have received the following letter from Mr. Rowland Gascoyne:—

Ashton Moss Colliery,
Audenshaw, near Manchester,
12th May, 1890.

To T. W. H. Mitchell, Esq.,
Midland Institute,
Barnsley.

GEOLOGY OF THE YORKSHIRE COAL-FIELD.

Dear Sir,—I quite intended being present at the discussion on Mr. Russell's paper at Sheffield to-morrow, but find it inconvenient to be so. In the general description of the geology of the Yorkshire Coal-field there is only one point I would

take exception to, that is in regarding the Rotherham Red Rock as Upper Coal-measures. (See page 101 of Vol. I. of the "Proceedings of the Federated Institution of Mining Engineers.") The difficulties surrounding such a classification are clearly shown on pages 120 and 121, where Mr. Russell goes into closer detail, and compares it with the Whitehaven Sandstone and the Upper Coal-measures of Scotland. The fact that it is in some places in South Yorkshire overlaid by true Middle Coal-measures does not favour the view that it is Upper Coal-measures, nor can the occurrence of Coal-measure fossils be regarded as proof that the Rotherham Red Rock is of Upper Coal-measure age, but as I pointed out in the discussion on the paper I read before the Midland Institute recently, the conditions under which we find the Rotherham Red Rock point to its being a re-deposited rock, and of purely local occurrence. If there are any exposed beds belonging to the Upper Coal-measures in South Yorkshire they are to be seen in the brickyard against Conisbro' Castle, which would amply repay Mr. Russell for a visit; but even with regard to these there are doubts as to their absolute identification.

I am, Sir, yours faithfully,
ROWLAND GASCOYNE.

The PRESIDENT—I think there is no doubt both gentlemen are right. The Rotherham Red Rock is, I have always understood, a purely local deposit, and its position is possibly due to the enormous throws and disturbances which meet together in the immediate neighbourhood of Rotherham.

Mr. W. H. CHAMBERS (Denaby)—Our sinkings are not touching the Red Rock, they are below it. I know the brickyard that Mr. Gascoyne refers to, and the limestone runs close up to it, and goes underneath it.

The PRESIDENT—But Mr. Gascoyne would consider the Magnesian Limestone as Upper Coal-measures. They are getting fairly up.

Mr. NASH—He would call them Permians; they are above the Coal-measures altogether.

The PRESIDENT—I do not see that, when you have interspersed with the limestone small bands of coal.

Mr. NASH—You do not find them true measures.

The PRESIDENT—Likely not.

Mr. NASH—For instance, you find coal in the Lias and other formations which do not belong to the Coal-measures at all.

Mr. W. H. CHAMBERS—There is no doubt as the sinking is proceeded with at Cadeby, we shall be able to ascertain the character of the measures higher up than they have hitherto been proved in Yorkshire. I do not know when we shall get to them as there is a great thickness of alluvial deposit overlying them. We have got 60 yards down and got no regular measures yet.

The PRESIDENT—I think it would be as well to adjourn the discussion as there may be some new light from the sinking operations.

Mr. NASH—Mr. Nevin's paper really relates to the same subject, but we have not got it before us.

The PRESIDENT—There is a paper by Mr. G. B. Walker on "Coal-cutting by Machinery." Mr. Walker says their manager from Ridgett Colliery will be glad to render any information, but as many of the plates have not been printed, and as we have made communications with regard to them and hope to get them in the next part, I think it will be better to adjourn the discussion until we have the means of discussing it fully before us. I think that concludes our business to-day.

ON THE DIFFERENCE BETWEEN THE SEAMS IN THE NORTHERN AND SOUTHERN PARTS OF THE YORKSHIRE COAL-FIELD AS SHOWN IN SOME OF THE DEEPER SINKINGS.

By John Nevin.

Several papers on the variation of the different seams in this coal-field have been read before this Institute by Professor A. H. Green and Mr. R. Russell,* the last one by that gentleman in January this year before the meeting of the Associated Institutes at Sheffield; but it occurred to the writer that it might be interesting, now that two or three of the deeper sinkings give between them the total thickness of the more valuable measures of the coal-field in each part of the county, to have on record in the Transactions of this Institute a few of these sections which would fairly show the different workable seams.

Commencing with the northern half (see Section 1, Plate I.) we find that Sharlston is the deepest pit at present sunk to the Haigh Moor Seam, which is reached at a depth of 508 yards; the measures below this, down to the Middleton Main or so-called Silkstone of West Yorkshire, we can get from sinkings at Soothill and Thornhill, or better still, in one sinking (see Section 3, Plate II.) at Roundwood, near Ossett. The Thornhill and Mirfield Collieries give us the next 200 yards down to the Low Moor beds, and below this to the top of the Millstone Grit we have to depend on short sinkings and surface outcrops, no pits having, so far as I know, been yet sunk through the Low Moor beds to the Halifax or Ganister coals.

Putting these together (as in Section 1, Plate I.), we have a proved thickness of 1,200 yards of Coal-measures, of which nearly all the workable seams are in the upper 800 yards, and the lowest 200 yards are of little value.

Looking over the Sharlston section, commencing at the surface, we find three coals, each about a yard in thickness, at depths varying from 50 to 105 yards; these are not much worked, and cannot be considered of much importance at present.

We then have about 200 yards with hardly any coal, and then come to the Scale Coal, 3 feet thick, and 20 yards below it the Stanley Main, the first important seam of the northern district.

This seam has been worked from its outcrop over a large area of country—north and east of Wakefield, and extending through the Stanley, Whitwood, Sharlston, and Featherstone Collieries to Pontefract and Castleford.

A fair section of it is as follows:—

	Ft.	In.	
Top Coal	1	6	
Dirt	0	8	
Coal	1	8	
Dirt	1	8	
Good Coal	3	0	
Total thickness	8	6	with 6 feet 2 inches of coal.

* See Professor A. H. Green on "Variations of Thickness and Character of the Silkstone and Barnsley Coal-seams in the Southern part of the Yorkshire Coal-field," Oct., 1875, Vol. IV., page 169. "Lithological Description of the Measures occurring in the Northern portion of the Yorkshire Coal-field," by R. Russell, Oct., 1875, Vol. IV., page 195. "The Flockton Coals and the Physical Conditions that led to their Formation," by R. Russell, Feb., 1877, Vol. V., page 48.

This seam yields a large portion of the West Yorkshire steam coal exported at Goole and Hull, and is sold as a second class house coal.

The Scale Coal, 20 yards above it, is a good house coal but is not much worked.

The next coal of importance is the Warren House Seam, 80 or 90 yards below the Stanley Main.

A fair section of this is:—

	Ft.	In.	
Top Coal	1	0	
Dirt	0	2	
Coal	2	3	
Dirt	0	9	
Coal	1	0	
Total thickness	5	2	with 4 feet 3 inches of coal.

This seam is not of first-class quality, and yields a second class steam coal; it is worked at Wheldale, Frystone, and other places.

In the Roundwood section it is represented by the Gawthorpe Coal, which is 3 feet thick, and has been much worked west of Wakefield, about Ossett, etc., as an engine coal, but it has not been worked south of Wakefield, nor, I believe, at any of the pits between Sharlston and Pontefract, although most of them are sunk through it.

The next important seam is the Haigh Moor, about 90 yards below the Warren House. This is a first class house coal, and is much worked all the way from its outcrop on the west and north (in which direction at Allerton it rises up to the Magnesian Limestone) to Castleford and Pontefract.

At Sharlston it has the following section:—

	Ft.	In.	
Coal	4	2	
Spavin	2	9	
Coal	1	2	
Dirt	0	4	
Coal	1	6	
Total thickness	9	11	with 6 feet 10 inches of coal.

This is more than the usual thickness; at Pontefract the top coal is 3 feet, dirt, 8 inches, and bottom coal, 1 foot 6 inches; towards the west, as at Roundwood, the two halves of this coal are divided by 30 feet of dirt, and are both worked separately with a thickness of 2 feet 8 inches to 3 feet each. With the exception of the Middleton Main this is the most valuable seam in the district.

We then have a depth of 80 to 100 yards, with little or no coal, but containing a thick sandstone, the Dewsbury Bank or Thornhill Rock, and we then come to the Joan or Mitchell Coal, 2 feet to 2 feet 6 inches thick; 16 to 20 yards below this is the Flockton Thick or Stone Coal, and about 20 yards below that again the Flockton Thin.

All these three, but especially the last two, have been largely worked near their outcrops, from Drighlington by Batley and Dewsbury to Thornhill, Flockton, and Emley; the Flockton Thick contains some good cannel, which is much worked at Morley and Batley, and this seam, in varying condition, can be traced continuously as far south as Sheffield. The Flockton Thin (called the Adwalton Black Bed near its northern outcrop) is a good house coal, 2 feet to 3 feet thick. They all seem to become of little or no value as they strike east of Leeds. (For full particulars of these seams, see Mr. Russell's paper, Vol. V., page 48.)

From the Flockton Thin to the Middleton Main Coal is about 80 yards, and from 20 to 40 yards below the former we find a variable group of coals, near Drighlington, forming one seam of inferior coals with several partings together, about 5 feet of coal and dirt; further south, at Thornhill and Flockton are two or three seams of clean coal, about 2 feet thick, one of which is generally worth working, and called the Old Hards.

Between this and the Middleton Main lies the Green Lane or Middleton Little Coal, which is only worked about Morley, where it is about 3 feet thick, and produces a good, hard steam coal.

We now come to the Middleton Main or so-called Silkstone of West Yorkshire, which is the most valuable seam of the district, in thickness varying from 3 feet to 4 feet 6 inches, and with various local names; it has been worked continuously from its outcrop on Emley Moor by Flockton, Thornhill, Dewsbury, Drighlington, Morley, Middleton, Woodlesford, Manston, Garforth, Micklefield, and Allerton, and by Ardsley and Stanley to Altofts, Whitwood, and Wheldale, and is now being sunk to at Sharlston.

In its best condition its section is as follows:—

Good Coal	3 feet 6 inches to 4 feet,
Bottom Coal	6 „

with a few inches of inferior coal and dirt underneath it. It is a good house and gas coal.

10 to 20 yards below this is the Wheatley Lime Coal, 2 feet to 3 feet thick, generally of poor quality and only of local value; and 30 to 40 yards below that, running very regularly at a depth of 50 yards below the Middleton Main, is the Blocking Coal, which, although very persistent and generally of good quality, is not often as much as 2 feet thick, and is therefore not of much value.

50 to 70 yards below the Blocking we have a variable group of two or three coals in the Cleckheaton district, called the Shirtcliffe Coals, one of them containing some cannel, and as they go east of Leeds running together and forming a 5 feet seam of fair house coal, called the Beeston Bed. If this seam continues in good condition as it goes south under the Middleton Coal it will be of much value.

150 yards below the Blocking Coal we have the Low Moor Black Bed; the measures immediately above this produced for years, and still to a small extent produce, the celebrated Low Moor and Bowling Iron: to the south of Low Moor there is no workable ironstone on it, but the coal becomes a first-class gas coal, generally about 2 feet 6 inches thick, and is much worked near Clifton, Cleckheaton, Dewsbury, Mirfield, and Thornhill.

40 yards below this is the Low Moor Better Bed, which is a wonderfully pure coal, but rarely above 18 inches thick; it seems to thin out to the south near Kirkburton and to the east towards Leeds, and, except locally, is of no value.

We then have 200 yards of nearly barren measures containing the Elland Edge Flagstones and then find the Halifax Hard Bed, 2 feet to 2 feet 6 inches thick, and 20 or 30 yards below it the Soft Bed, 1 foot 6 inches thick; the first is of poor quality, the latter generally good and makes first class coke, the measures between and near them contain several beds of fire-clay and ganister which are valuable locally.

A few yards below the Soft Bed we reach the Rough Rock or Millstone Grit, the base of the productive Coal-measures.

Turning now to the southern part of the coal-field we find South Kirby is the deepest pit yet sunk to the Barnsley Bed.

At 185 yards it passes through the Shafton Coal 3 feet thick, and between 250

and 315 yards the three seams, each nearly 3 feet thick, which are met with at Sharlston, between 50 and 105 yards; all these coals have been worked locally, but are not of much value, while the thicker and better seams are in the market.

At 480 yards we have the Woodmoor Coal 2 feet 4 inches thick, and at 509 the Winter Coal, which is the same as the Scale Coal in the Sharlston section; both these coals have been much worked about Criggleston and Wakefield, and the identity of the Scale Coal and Winter has been often proved.

Below this we find the measures vary greatly from those further north; instead of having the thick Stanley Main 20 yards below the Winter Coal, we find several thin seams between 526 and 563 yards, called the Kents Thin and Thick Coals, and corresponding with what are sometimes called the Beamshaw and Mapplewell Coals, and at 634 yards, being almost the same distance below the Sharlston Low Coal (*i.e.*, 315 yards) and the Winter Coal (*i.e.*, 120 yards) as the Warren House Coal is at Sharlston, we find the Barnsley Bed 9 feet 8 inches thick.

There is no need for me to describe this bed; its thickness, uses, and value are well known to all the members.

Continuing the measures downwards, we find at Barrow Colliery that the first bed of importance below the Barnsley is the Swallow Wood Coal about 60 yards down. This bed, although only 3 feet thick here, is often much thicker, it varies much in quality, in some places being good, and in other of little or no value; it seems to occupy the same position as the Haigh Moor Seam of the northern district.

About 70 yards below this is the Lidget Coal, which is worked locally as a house coal, but cannot be said to be of general value; it does not seem to be represented in the northern section.

75 yards below this again is the Flockton Thick, not often worked in the southern district. Comparing the thickness of the measures in the two districts, we find that at Barrow the Flockton Thick is 200 yards below the Barnsley and 145 yards below the Swallow Wood, while in the north it is 205 yards below the Warren House and 117 yards below the Haigh Moor, the thickness of the measures being thus practically the same.

30 yards below we have the Flockton Thin, and 30 yards below that the Fenton Coal, neither of which are much worked in the district.

20 yards lower is the Parkgate; this seam has generally from 4 feet 6 inches to 5 feet of good coal, and after the Barnsley and Silkstone, is the most valuable coal of the South Yorkshire district. About Sheffield it is used as a furnace coal, in other places as a house coal, and near Rotherham part of this seam is a first-class gas coal.

37 yards below this is the Thorncliffe Thin Coal, generally 3 to 4 feet thick; this is much worked as a steam and furnace coal, and 60 yards below this, or 375 yards below the Barnsley, we come to the Silkstone Coal.

This divides with the Barnsley Bed the honour of being the most valuable of the district, and is worked continuously, from Cawthorne on the north, through the whole length of Derbyshire to the southern boundary of the coal-field near Nottingham, yielding a first class house and gas coal. At present, however, there seems some doubt whether it extends to the east, under the Barnsley Bed, towards Rotherham, etc., with a workable thickness, some sinkings and borings having proved it very thin; but this thinning may be only local.

Below the Silkstone, at a depth of 67 yards, is the Whinmoor Coal, which has not been much worked. It has, however, recently been sunk to below the Silkstone.

My own knowledge goes no further down than this, but I should be very glad if any gentleman having local knowledge would continue this section down to the Millstone Grit.

If we compare the two sections we find it almost impossible to correlate the seams below the Flockton Coals.

Professor Green and Mr. Russell have described how the Barnsley Bed becomes worthless about Crigglestone, and the Silkstone about Cawthorne.

There is always a tendency to call a good seam in one district by the name of a well-known one in another, and to think that a thick seam in one must be the same as a thick seam in another; in this way we have heard it said in the Darton district that the Stanley Main and the Barnsley Bed were the same, and this is how the Middleton Main of the northern district came to be called the Silkstone. I think, however, that the gentlemen of the Geological Survey are right, and that the Blocking Coal represents the Silkstone.

We find that the distance from the Sharlston Coal to the Warren House or Barnsley, and from the latter to the Flockton Thick being practically the same in both districts, the thickness from the Flockton Thick to the Middleton Main is nearly 100 yards and to the Blocking about 150 yards only, while at Barrow from the Flockton Thick to the Silkstone is 165 yards.

The position of the Whinmoor below the Silkstone agrees also very well with that of the Beeston Bed below the Blocking Coal, being about 67 yards in the south, while the Beeston Bed at Middleton, near Leeds, is 60 yards below the Blocking Coal and 96 yards below the Middleton Main, the corresponding coals at Thornhill and Mirfield being from 50 to 75 yards below the Blocking.

On the accompanying plan (Plate III.) I have shown approximately the southern limit of the present workings in the Middleton Main Coal, and where the break between it and the Silkstone exists north of Cawthorne, it seems to me that we shall have to wait until new collieries further to the east prove the seams in the debatable strip of ground.

The subject is interesting, not only from a geological, but from a commercial point of view, because if the Middleton Main and Silkstone are the same, we are pretty sure of having a good workable coal extending from one end of the coal-field to the other, but if not there will be a strip of unknown width, in which only the thinner seams will be found.

The facts seem to me to point to the following conclusions:—

1. That we have one or two of the thinner seams as the Winter Coal and the Flockton Thick, which are continuous, and can be identified through the whole of the county.
2. That in the northern part we have three main workable seams; the Stanley Main, the Haigh Moor, and the Middleton Main, with the Warren House and the Beeston as second class ones.
3. That in the southern part we have the Barnsley, the Parkgate, and the Silkstone, with the Swallow Wood and Thorncliffe Thin as second class ones.
4. That the workable thickness of coal, although not in the same seams, and the general thickness of the measures are pretty much the same in both districts.

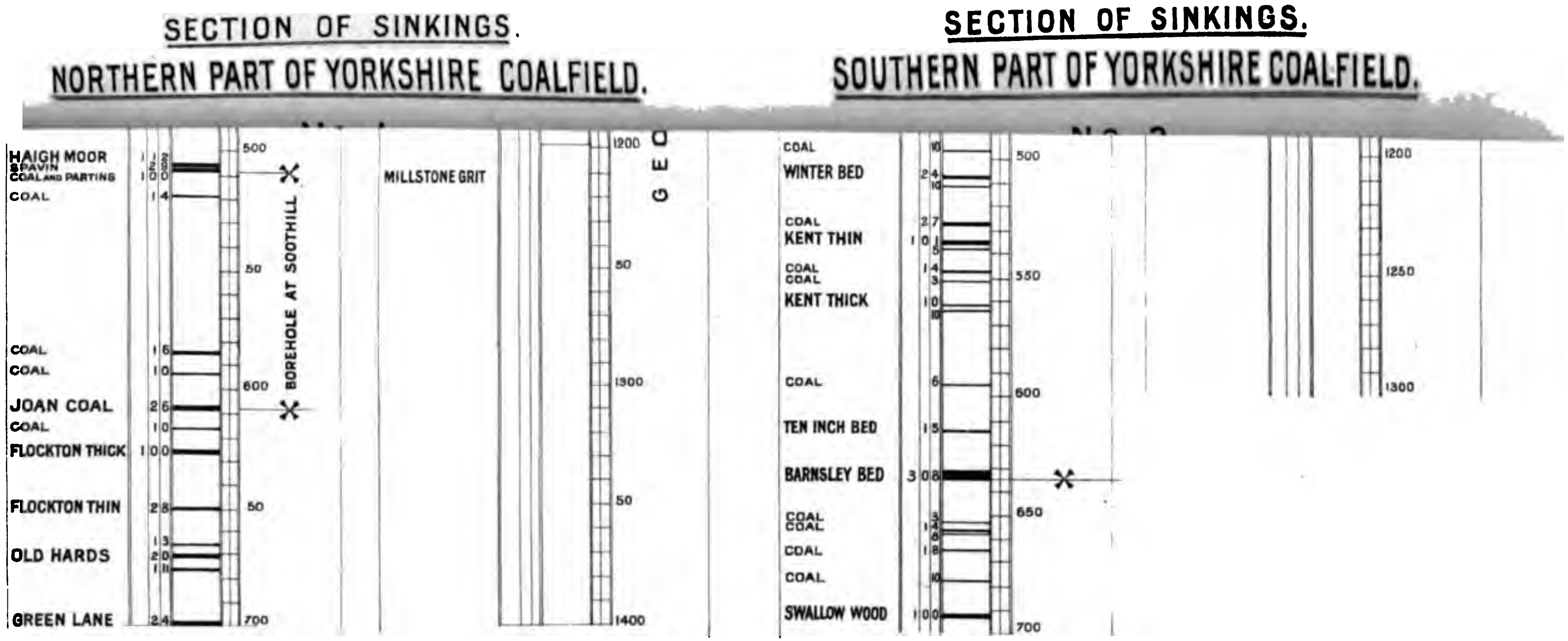
In conclusion, I beg to acknowledge the kindness of Messrs. Kell, G. B. Walker, and J. O. Greaves in giving me sections.

KEY TO PLAN. (PLATE III.)

ILLUSTRATING MR. J. NEVIN'S PAPER ON THE YORKSHIRE COAL-FIELD.

No.	Name.	Depth.	Coal Worked.	No.	Name.	Depth.	Coal Worked.
1	Clifton	112	Black Bed.	50	Whitwood	150	Stanley Main.
2	Hartshead	150	"				
3	Stanley	120	"	51	Snydale	225	"
4	Liversedge	170	"	52	Streethouse	230	"
5	Wroes	180	"	53	Featherstone	250	"
6	Park Farm	165	"	54	Nostell	—	"
7	Park	150	"	60	South Kirby	634	Barnsley.
8	Mirfield Moor	154	"	61	Monkton	479	"
9	Dark Lane	197	"	62	Carlton	287	"
10	Dewsbury Moor	240	"	63	Monk Bretton	290	"
11	Inghams	276	"	64	Wheatley Wood	215	"
12	Howden Clough	295	"	65	North Gawber	107	"
				66	Gawber Hall	105	"
18	Bruncliffe	—	Middleton Main.	67	Craiks	160	"
				68	Ross	185	"
19	Morley Main	150	"	69	Old Oaks	293	"
20	Howley Park	100	"	70	New Oaks	325	"
21	Morley West End	120	"	71	Houghton Main	516	"
22	Soothill Wood	200	"	72	Darfield Main	337	"
23	Thornhill	115	"	73	Mitchell's Main	350	"
24	Hartley Bank	200	"	74	Wombwell's Main	224	"
25	Roundwood	343	"	75	Lundhill	214	"
26	West Ardsley	—	"	76	Corton Wood	220	"
27	East Ardsley	218	"	77	Wath Main	300	"
28	Lofthouse	—	"	78	Manvers	300	"
29	Woodlesford	80	"	79	Denaby	447	"
30	Stanley Victoria	471	"	80	Thrybergh	288	"
31	Haigh Moor	327	"	81	Roundwood	—	"
32	Newland	485	"	82	The Holmes	180	"
33	Altofts	420	"	83	Treeton	350	"
34	Allerton	—	"	84	Kiveton Park	400	"
35	Wheldale	450	"	85	Shireoaks	515	"
				91	Higham	210	Silkstone.
41	Frystone	269	Haigh Moor.	92	Dodworth (Church Lane)	210	"
42	Pontefract Park	477	"	93	Strafford	240	"
43	Glasshoughton	347	"	94	Barrow	470	"
44	Sharlston	513	"	95	Hoyland	508	"
45	Parkhill	327	"	96	Rockingham	337	"
				97	Nunnery	216	"

To illustrate Mr. J. Nevin's paper "on the Yorkshire Coalfield."



Federated Institution of Mining Engineers Proceedings 1889-90.

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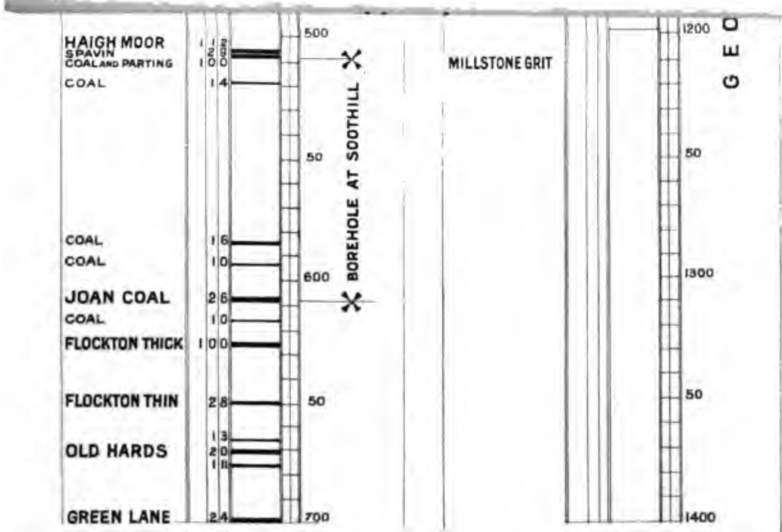
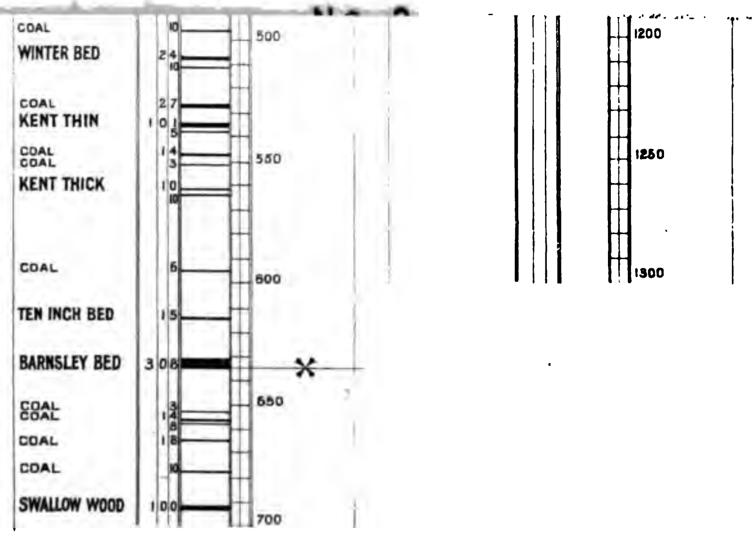
SECTION OF SINKINGS.

NORTHERN PART OF YORKSHIRE COALFIELD.



SECTION OF SINKINGS.

SOUTHERN PART OF YORKSHIRE COALFIELD.



Federated Institution of Mining Engineers
Proceedings 1889-90.

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To illustrate Mr J. Nevin's paper "on the Yorkshire Coalfield."

CTION OF SINKING AT ROUNDWOOD COLLIERY FROM SURFACE TO SILKSTONE COAL.

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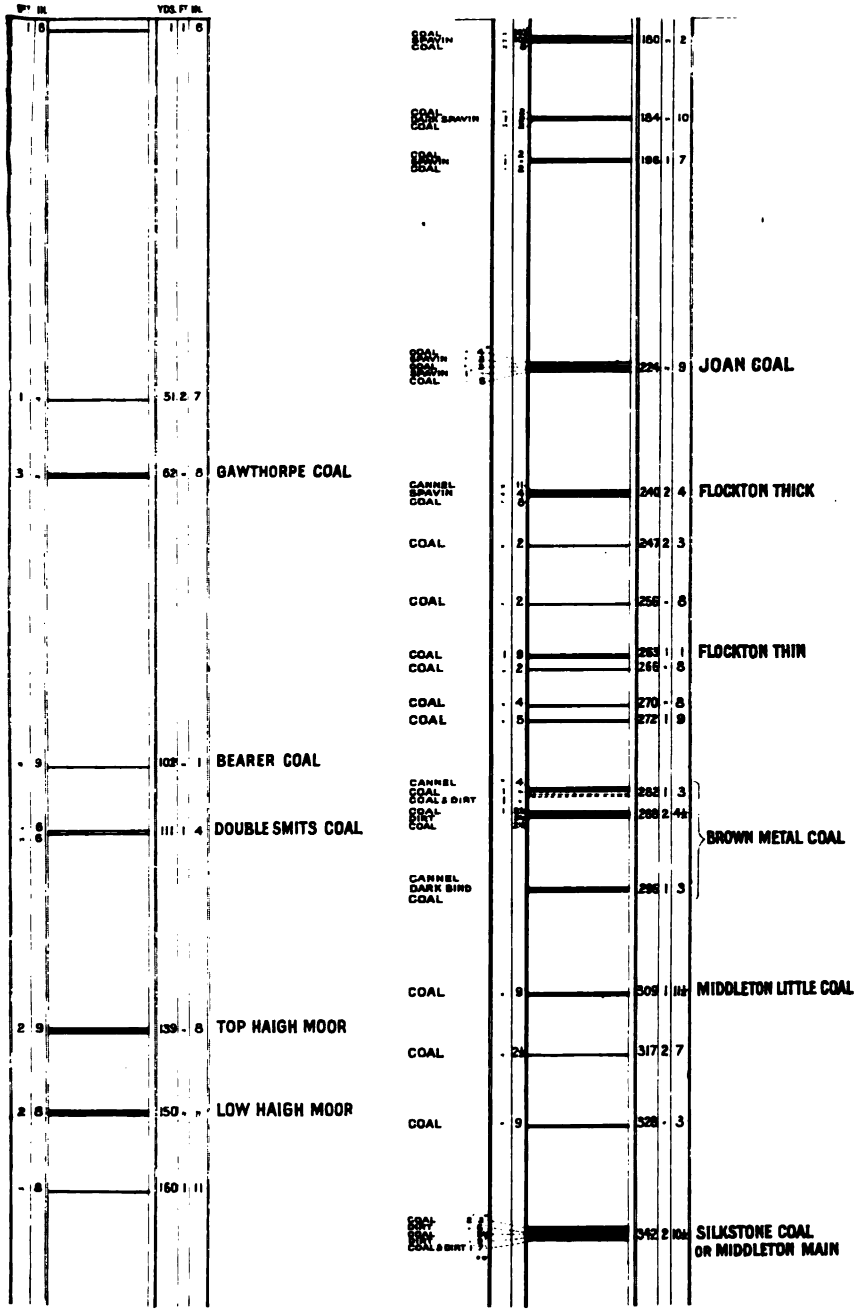

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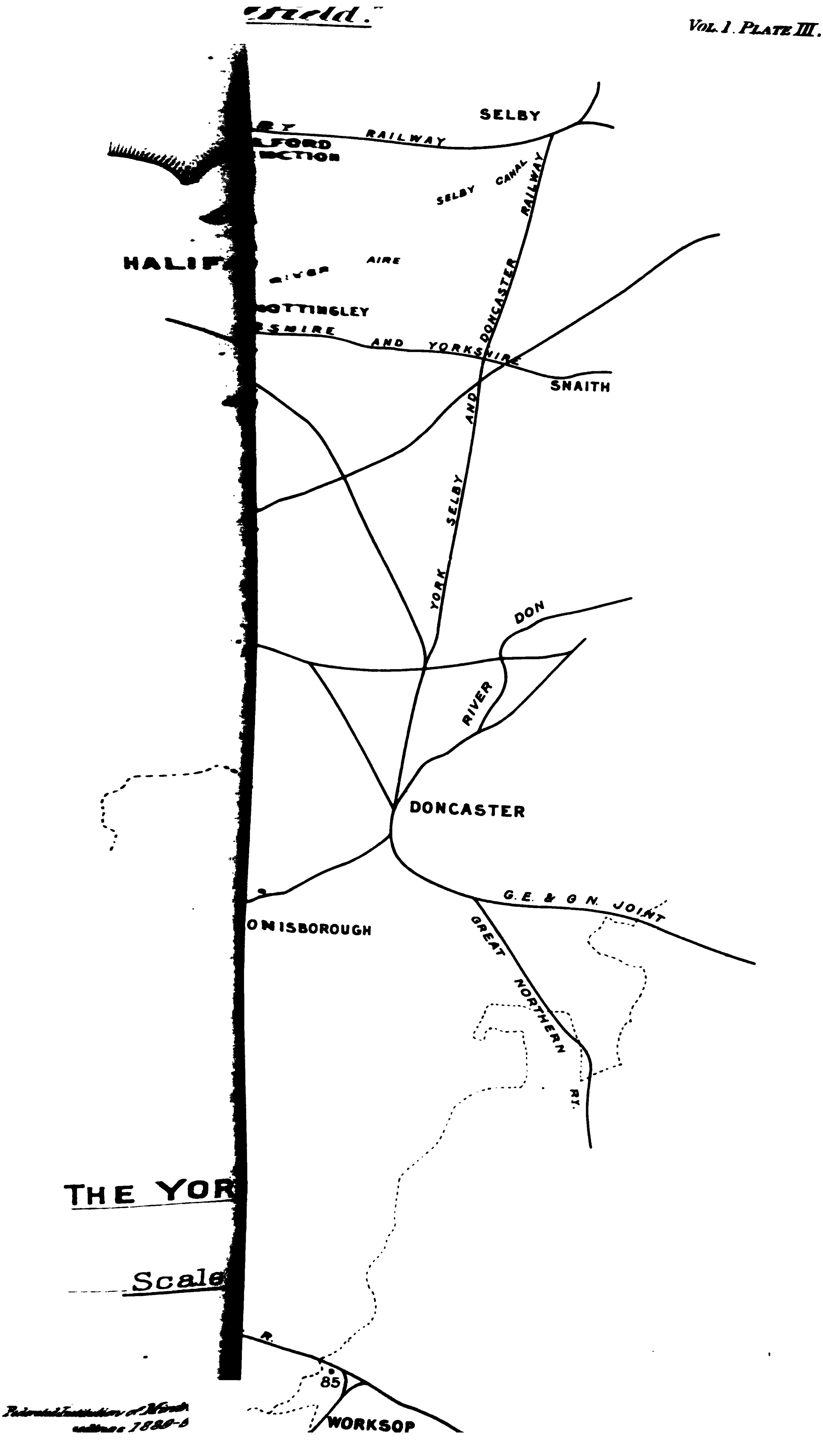
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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, FEBRUARY 8TH, 1890

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, which were confirmed.

The SECRETARY reported that since the last general meeting two meetings of the Council had been held, and among the business done it had been decided to print Mr. Hugh Boyd's memoir of the late Mr. E. F. Boyd in full, as a separate publication, with a photographic portrait, to be issued to the members of the Institute. An abstract of the memoir, consisting of an account of the purely professional career of Mr. Boyd, would be published in the Proceedings of the Federated Institution.

The following gentlemen were elected, having been previously nominated:—

MEMBER—

Mr. Daniel Henry Bayldon, Mining Engineer, Thames Gold-Field, New Zealand; and 3, Drapers' Gardens, London, E.C.

ASSOCIATES—

Mr. Sidney Bates, Surveyor, etc., The Grange, Prudhoe-on-Tyne.
Mr. John Bell, Under Manager, Wardley Colliery, Newcastle-on-Tyne.
Mr. Thomas Hepburn, Under Manager, South Street, Langley Park, Durham.
Mr. Robert Richardson, Under Manager, Throckley Colliery.
Mr. George D. Ridley, Colliery Surveyor, Tudhoe Colliery, Spennymoor.
Mr. Andrew Watson, Colliery Engineer, New Seaham Colliery, Sunderland.

The following gentlemen were nominated for election:—

MEMBER—

Mr. Hiram Craven, Jun., Mechanical Engineer, Sunderland.

ASSOCIATE—

Mr. Edgar Ormerod Bolton, Mining Engineer, Exors. of Col. Hargreaves, Burnley.

In the absence of the author, the SECRETARY read the following paper by Mr. D. H. Bayldon, on "The Hauraki Gold Mining District (Northern Section), Auckland, New Zealand."

THE HAURAKI GOLD MINING DISTRICT (NORTHERN SECTION), AUCKLAND, NEW ZEALAND.

By D. H. Bayldon, M.E., Thames, New Zealand.

The Hauraki mining district, in the Province of Auckland, New Zealand, lies between latitudes 36° 25′ and 37° 40′ S. and longitudes 175° 20′ and 176° 0′ E., is about 100 miles long by an average of 25 miles wide, the greater portion being known as the Coromandel Peninsula.

It is bounded easterly by the Pacific Ocean and westerly by the Firth of Thames and the beautiful fertile valley of that name, the extreme northern limit being Cape Colville, and extends southward beyond Te Aroha mountain, 3,173 feet high.

The country for the most part is rugged and mountainous, covered with dense forest of evergeen trees, intersected by innumerable streams of various sizes, which afford at all times of the year a magnificent supply of pure water for mining, timber floatage, and domestic use.

The timber on the ranges is of vast extent. Here is found the celebrated Kauri pine, from 70 to 150 feet high, some of the boles of which have been known to exceed 20 feet in diameter. Other valuable timbers exist, suitable for building, cabinet, fencing, mining, and domestic purposes. The Kauri gum, a hard substance somewhat like amber in appearance, and which is exuded from the pine of that name, is found in the existing and extinct forests in great profusion, and is a source of wealth to the country; it is exported to England and America, where it is highly esteemed and manufactured into the finest carriage varnish.

The valleys are salubrious and fertile, composed of deep alluvium, and are, to some extent, cultivated by the Maoris, miners, and settlers. The crops are such as are grown in England. All English fruits are abundant and good. Stock of all descriptions thrive and do well.

The situation of the Hauraki mining district is somewhat unique as a gold-field, the facilities offered for the export or import of material being all that can be desired, sea carriage being afforded almost up to the pit mouths in the instances of Thames and Coromandel. The noble and picturesque harbour of Auckland is within 40 miles of the former and 30 miles of the latter town, where ships of any draught may lie and discharge at the wharves with the greatest safety.

Local steamers, carrying passengers and freight, run at regular and frequent intervals between Auckland, Thames, Coromandel, and Mercury Bay, from whence they distribute their freight to other points by drays, coach, or river.

The Thames or Waihou river drains the south-western section of the district; it is navigable for small steamers and craft for some 60 miles on its course. Inside the river, for several miles, exists a natural harbour, suitable for vessels up to 600 tons register. The land is rich and fertile, forming a broad valley 15 to 20 miles wide, perfectly flat, intersected by other streams. The ground is somewhat swampy, which is natural from its conformation, but for the most part easily drainable. Here the *Phormium tenax*, or native flax, covers large areas and fringes the river banks; the white pine, a very useful timber, is also abundant. Much of this land, especially in the upper part of the valley, is reclaimed, and flourishing farms are to be seen as far as the eye can reach.

The lands on the eastern bank of the river are now nearly all occupied by a hardy, industrious class of farmers, many of whom are now and have in days gone by been engaged in mining pursuits.

Such is a brief outline of the Hauraki mining district, and it will be seen that mining and agriculture can go hand in hand. Twenty years ago it was a howling wilderness, now there are many small towns and villages, the country dotted over with farms, the miners penetrating the hills in search of the precious and other metals, and the country made accessible by roads and bridges. The future of such a country is not hard to predict.

The principal centres of mining in the district are Coromandel, Hastings, Thames, Hikutaia, Ohinemari (comprising Karangahake, Owharoa, Waihi, and Waitekauri), Te Aroha, including Waiorongomai.

Gold was first discovered at Coromandel in the year 1851, and attracted a considerable number of miners, but through native troubles, and superior attractions elsewhere, the diggings became comparatively deserted till 1861, from which time mining has been carried on, with more or less success, to the present day. Considerable tact required to be displayed in dealing with the natives to induce them to open their lands to the miners for prospecting and mining. All these difficulties have for many years been overcome; cordiality and mutual good understanding now prevails on both sides.

Coromandel is situated on a beautiful little harbour, and mining for gold is carried on from the sea beach across the main range toward the east coast. Coal and other minerals are found throughout the district, but are undeveloped.

The principal gold mines are the Kapanga and Coromandel (English companies), Tokatea, West Tokatea, Royal Oak, Pride of Tokatea, Success, Onslow, and many others.

Throughout this district the outcrop of a main or mother reef can be traced for many miles, averaging 25 to 30 feet thick, with a northerly strike and westerly underlie of about 45 degrees. It has not been found payable, but the lateral veins, which have an east and west strike and northerly dips of varying angles, are found to yield good paying ore, which, as a rule, lies in "chutes" or chimneys of varying widths and depths. These lateral veins vary from a few inches to several feet in thickness. The Tokatea Mine, in which this system of reefs is well illustrated, is situated on the main range, the highest point being about 1,400 feet above sea-level; it is worked by adits down to a depth of 900 feet, the lowest level being about 2,500 feet long.

The Kapanga Mine is situated about one mile westward of the main reef; two well defined reefs have been worked from the surface to a depth of 550 feet. It is worked from a main shaft, properly equipped with pumping and winding machinery, capable of going to a much greater depth.

Some of the ore from this mine was exceedingly rich, and in places highly charged with metallic arsenic, which, in the course of amalgamation, had the effect of sickening the quicksilver, which, consequently, did not do its work, entailing considerable loss of the precious metal.

The Coromandel Mine is situated on the sea shore, above high water mark. The company are doing good work, opening up new blocks 280 feet below sea-level.

The pumping and winding machinery is situated on the sea beach, the mine being worked by two shafts about 450 feet apart. The inland shaft, being about 120 feet above sea-level, and the deepest by 100 feet, is connected by sweep rods to the pumping engine, the water being pumped to the 180 feet level, from whence it runs back to the seaward shaft, and is then forked to the surface. The drainage water from the mine is settled in a reservoir and used for milling purposes.

The country rock in which the lodes are encased is of igneous origin, of a tufaceous nature, highly charged with undecomposed pyrites, below water-level, sometimes coarse and rotten, in other cases fine grained and hard, and has been

termed "tufaceous sandstone," and in this class of country rock only have the lodes been found payable. Alternating with the tufaceous sandstone are to be found slates, diorite-porphyry, and felsites.

Hastings, some 20 miles south of Coromandel, is a small mining township. Considerable quantities of gold have from time to time been found in the various gullies and spurs off the main range, chiefly in decomposed slate and tufaceous sandstone. No deep mining of any consequence has been done here.

Thames is the centre and most important locality in the Hauraki mining district. It was opened for mining in the latter part of the year 1867, and has been constantly worked since that date.

The population was at one time 10,000 to 11,000, but being chiefly composed of miners, otherwise diggers, who are a roving set of men, attractions elsewhere has reduced the number to something like 4,500 at the present time.

The auriferous portion of the Thames is several miles wide, and the distance back into the ranges uncertain, as not more than about six miles in a straight line has been explored for gold.

The country rock is composed of tufaceous sandstone, alternating with diorite or andesite dykes. The latter are extremely hard to penetrate, and are known locally as "hard bars." The highest points in the locality are chiefly composed of this class of rock. The country is broken and irregular, intersected by gullies and cracks, which afford excellent opportunities for mining by means of adits or tunnels.

The lodes have varying strikes between 10 degrees and 80 degrees north-east and usually underlie to the north-west at angles ranging from 22 degrees to 80 degrees from the horizon. They are variable in thickness, from a few inches to 20 feet, and all are more or less gold-bearing while traversing the tufaceous sandstone.

The pay ore, as is usual, lies in "chutes" of varying lengths and depths, the best paying reefs have hard walls, to which the quartz, in a great measure, adheres, which gives the impression that when the rocks were in a state of fusion they emitted certain gases, which, with other combinations when the rocks cooled, caused the deposition of gold in the veins. The deposition of gold is especially noticeable where lateral breaks occur, and which have the appearance of water channels.

Where the break does not cross the lode the chute of rich ore is of much greater extent, and the lode richest on that wall which has been subject to fracture, and the deposit of gold becomes weaker the further it recedes from that fracture. In many instances where a break crosses the lode the deposition of gold will be at the junction, and so marked is this in some instances that the cross courses are followed for the purpose of intersecting the junctions, and the lodes only worked at those particular points. The pay ore forms a pipe or chimney at the junction. Black veins, rich in pyrites, striking from the country rock into the lodes is a most fruitful source of gold. Flinty veins, barren in themselves, frequently run parallel with a lode, and when a contact takes place there is almost a certainty of gold being deposited.

There are also at the Thames several main slides or clay cross courses, which have an influence on the deposition of gold. The lodes are always more productive when in contact or in the immediate vicinity of these slides, and, moreover, the lode is not productive on both walls of the slide but usually on the hanging wall contact. (Plate I.)

The veins are very numerous and sinuous in their course, and frequent junctions occur, which complicates mining to a very great extent. As a rule the lodes maintain their underlie well. It may be as well to mention that where variations in strike and dip occur, the productiveness of the lode is influenced.

All these eccentricities entail upon the management constant care and watchfulness, as many instances have been known of mines abandoned as unprofitable on further development turning out highly profitable dividend paying concerns.

The mines, for the most part, are small, none exceeding 100 acres, some of the richest have not exceeded a few acres in extent.

The principal mines are worked from shafts on the low ground adjacent to the sea beach, and the workings are, for the most part, below sea-level. The deepest shaft is 748 feet, being over 720 feet below the sea. No trouble is experienced from sea water, the whole of the drainage being coped with by a main pump.

An assessment is made annually on the various companies benefited by its operations; it is by that means maintained and managed by a board elected from the contributors.

The pumping machinery consists of a low pressure Buhl engine of 250 horse-power, 82 inch cylinder, 8 feet stroke, with a 25 inch column, and four Cornish boilers; two balance bobs, one at the surface, the other at the 300 feet level, placed over a shaft 12 feet by 8 feet inside measurement, depth of shaft 640 feet. This machinery at present does all the pumping for the field down to the 500 feet level, working about six strokes per minute.

Mining in the hills is carried on by means of adits, of which there are a great number, varying in length from over half a mile to a few hundred feet.

Roads and tramways are constructed up the creeks, by means of which the ore is brought to the flat and distributed to the various reducing plants for treatment.

There are about 180 stamps at work in seven mills, a Newberry-Vautin chlorination plant, and several other establishments for the treatment of tailings by grinding processes.

All these mills are driven by water power. The water has been brought on to the ground by a water race, fifteen miles long, constructed by the Government, and now administered and controlled by the Thames County Council, who let the water at a moderate rental per cubic foot per week—one cubic foot being equal to about 12 horse-power, consequently, crushing operations are conducted at a very low cost. This water is not only useful for milling purposes, but is supplied to the foundries, cabinet factories, for household purposes, and small machinery generally.

In addition to the peculiarities mentioned in connection with mining at the Thames, it has been proved beyond doubt that the gold not only lies in chutes, but that these chutes have a southerly dip, and strike across the reefs at a low angle. (Plate II.)

Carbonic acid gas is frequently found in the mines below sea level; it is not noticeable except during easterly weather, the prevailing winds being westerly. Several fatalities have occurred through its sudden influx, but greater caution is now observed and accidents are avoided.

Mining at Thames is carried out in a thoroughly systematic manner. The machinery is of a superior description, subject to biennial inspection by a Government officer. The administration of the gold-field is conducted by the warden or magistrate, who hears and decides all cases of dispute which may arise from time to time.

The southern portion of the district, including Hikutaia, Ohinemari, and Te Aroha, are most interesting. The lodes are different to those at Thames and northward, and different classes of machinery are being put up for treating the ores, which are of a much more complex nature.

A short notice would not do them justice, therefore, as time will not permit, I have deemed it preferable to confine the foregoing paper to the northern section only.

Illustrate Mr. Bayldon's paper on "The Hauraki Mining District, New Zealand."

FIG. 1.

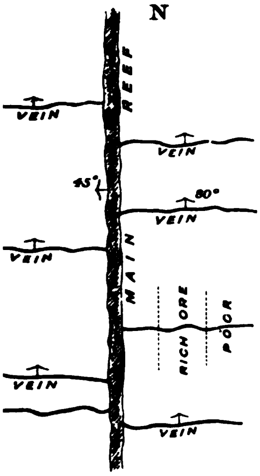


FIG. 2.

FIG. 3.

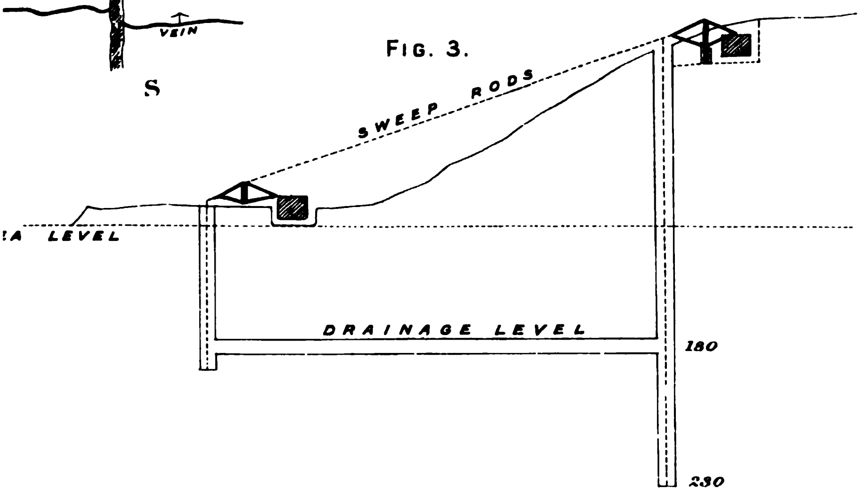


FIG. 4.

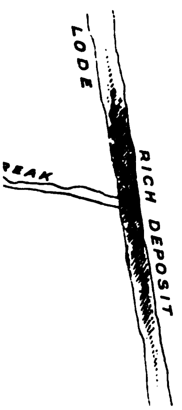


FIG. 5.

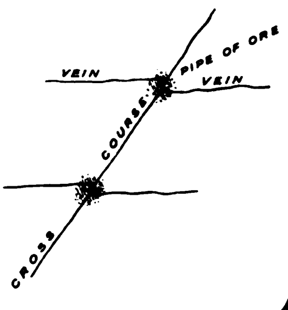


FIG. 6.

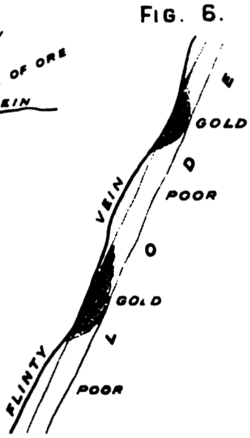
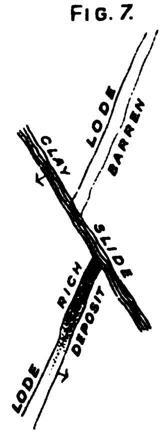


FIG. 7.



Institution of Mining Engineers
Proceedings 1889-90.

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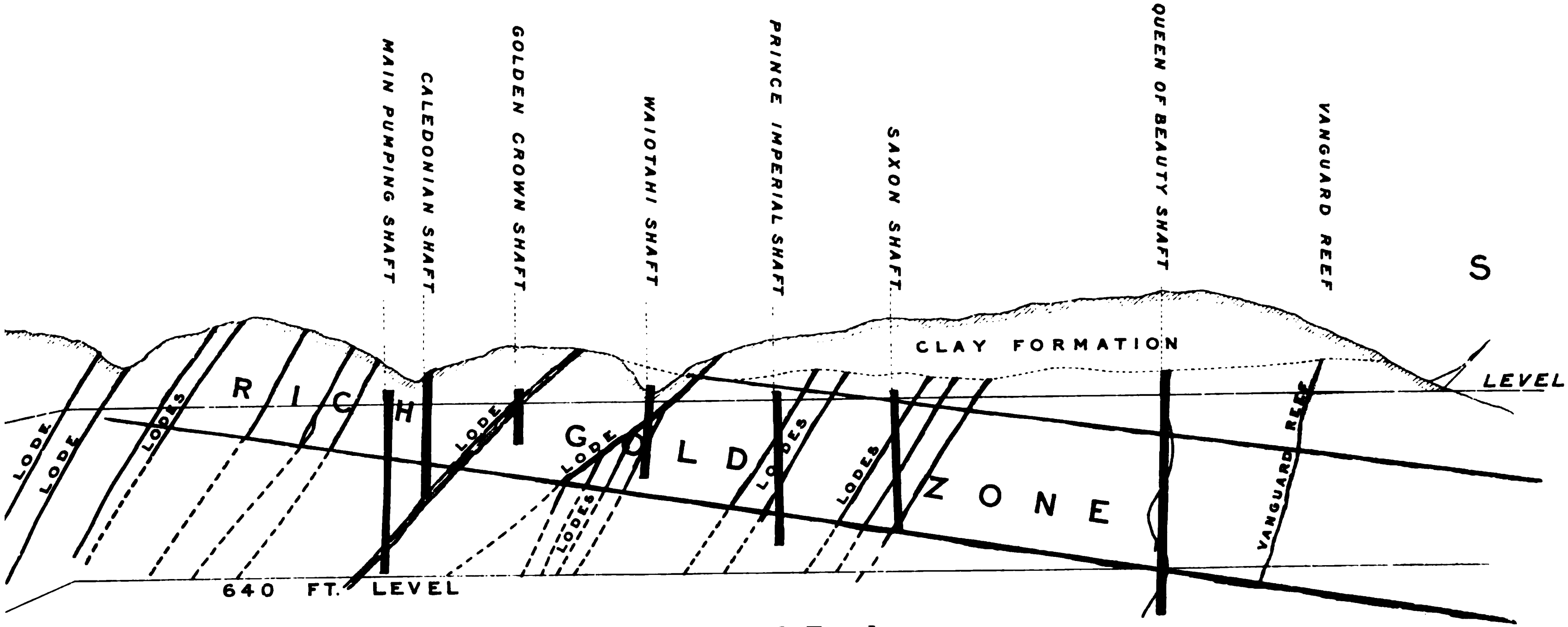

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Federated Institution of Mining Engineers
Proceedings 1889-90

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The PRESIDENT said, the author of the paper, who had that day been elected a member of the Institute, had, unfortunately, been obliged to leave for Africa. The paper was postponed from the last meeting in order, if possible, that Mr. Bayldon might be present, but as this was not possible, it might be well if there were any questions to ask or remarks to make on the paper that these should be forwarded, through the Secretary, to Mr. Bayldon, in order that that gentleman might reply in time for the adjourned discussion.

There being no remarks offered,

The PRESIDENT moved that a vote of thanks be accorded to Mr. Bayldon for the paper, which was apparently very full of information on the subject of the gold-fields in New Zealand.

Mr. C. Z. Bunning's paper on the "Warora Coal-field, India," was opened for discussion.

The PRESIDENT said he was glad to see the author of the paper present. Had he any further information to give by way of introducing the discussion?

Mr. BUNNING said he had not much to add, and as the other paper on the agenda was of more interest to the members, he would prefer that this be taken last.

Mr. A. L. STEAVENSON proposed a vote of thanks to Mr. Bunning. He said the paper was not one which could be very much discussed, but both this and the paper just read would be very valuable additions to the Proceedings, and of great assistance to anyone about to visit the districts described. He had read Mr. Bunning's paper carefully; there seemed to have been a great deal of labour involved in its preparation, and the writer deserved very much credit for the way in which he had stored his information.

The PRESIDENT thought it might perhaps be as well, if anyone had anything to say on the paper, to follow the order of the agenda.

Mr. THOS. BELL (H.M. Inspector) asked if it was compulsory under Act of Parliament in India to record every accident, however trifling? If so, the relative number of accidents there appeared to be very much lower than in this country, the ratio in England being nearly double, if, as he understood from the paper, every little accident was reported.

Mr. BUNNING thought he had remarked in his paper on this head that every accident which incapacitated a man from work for 48 hours had to be reported. With reference to Acts of Parliament, coal mines were included in the Factories Act; there was not a separate Mines Act.

Mr. THOS. BELL—The Factories Act being a Government Act?

Mr. BUNNING—Yes. The only matter to which he would like to draw the attention of any mining engineer going abroad, and especially to India or the Brazils, was with regard to the water. They should take care to avoid illness from parasites which the water of the mines contained; and all water before use should be properly filtered. He was in India four years, and his recent illness was due to ignorance of the dangers from the source mentioned.

Professor LEBOUR asked if there were any plant remains at all in the coal-seams at Warora?

Mr. BUNNING—Yes, the ordinary *calamite* is found there, but very rarely.

Professor LEBOUR—Is that all?

Mr. BUNNING—Yes.

The PRESIDENT said he had very much pleasure in seconding Mr. Steavenson's proposal. Their most cordial thanks were due to Mr. Bunning for his paper. With regard to the warning as to water, although of course a very proper one, the remark would apply to all sorts of impure water, at home or abroad, and mining water was often impure.

The vote of thanks was agreed to with acclamation.

Mr. TATE'S paper on "Winding, Banking-out, and Screening Plant at East Hetton Colliery" was opened for discussion.

The PRESIDENT asked if the author of the paper had anything to add? If not, he would invite the other members to discuss the subject.

Mr. TATE said he had very little to add. He had ascertained that previous to using the belt they picked out rather better than a half per cent.; now it was about 1¼ or 1½ per cent. of stone.

The PRESIDENT—You have increased the quantity removed?

Mr. TATE—Just about doubled it.

Mr. WILLIS—Trebled, is it not?

Mr. TATE—No, not quite. It varied from a half upwards before; now it is 1¼ to 1½.

The PRESIDENT said the question of screening and cleaning was a matter of importance, deserving, in the coal-fields of the North, as well as elsewhere, special attention, so much so that he was asked the other day to take into consideration the question of spending between £5,000 and £10,000 in this respect; and when such large sums as this were involved, the matter became one for serious consideration. Another paper, by Mr. Forster and Mr. Ayton, had been read on the same subject, and he hoped both this and Mr. Tate's paper would elicit much discussion.

Mr. BELL thought the President would naturally be anxious to have full information on the subject.

The PRESIDENT—Yes, very full, before spending so much. As he mentioned at the last meeting, he had seen Mr. Tate's arrangement, and was very much pleased with it.

Mr. J. G. WEEKS asked if Mr. Tate had just one kick-up, and, if so, what quantity per day could be put over it? What was the average daily quantity?

Mr. TATE said the apparatus had not been fairly tried at their pit; the most they had put over it was seventy scores.

Mr. J. G. WEEKS—Over one screen?

Mr. TATE—Yes, one screen; one kick-up; but they could do over double that.

The PRESIDENT asked what tonnage seventy scores represented?

Mr. TATE—Over a thousand tons.

Mr. BELL supposed it was not fully occupied.

Mr. TATE—Not half.

Mr. BELL asked how the weighing was arranged? He saw the tubs came out in front according to the diagram on the wall, but where was the indicator of the machine?

Mr. TATE explained the diagram. The machine was not finished yet, but it was intended to be hung on four rods within the kick-up; the tub could be weighed full and again empty when the kick-up brought it back to its original position. This was the only place where the machine could be arranged so as to weigh the tub full

and empty. Messrs. Pooley thought it would work nicely, Of course it was not always necessary to weigh the tub full and empty; they would weigh it either full or empty, or both, as circumstances required.

Mr. BELL asked whether boys or men were employed on the belt?

Mr. TATE—All boys.

Mr. A. L. STEAVENSON—I think you should ask us to go and see it and discuss it there.

Mr. TATE—We shall be glad to see you at any time.

Mr. BLACKETT cited a colliery in Derbyshire where a thousand tons a day went over one kick-up, and there the full tub was pulled in and the empty one pulled out. Mr. Tate's was an improvement on that, for the tub ran through the kick-up and a full tub coming displaced the empty one.

Mr. BELL—Yes, that is a saving of time.

Mr. STRATTON said he did not consider a thousand tons a day a large quantity to deal with, but he thought it was perhaps rather an extreme case to say that the quantity going over the one machine could be doubled. If the apparatus worked full nine hours a day that only allowed, on the seventy scores Mr. Tate referred to, about twenty-four seconds for each tub; he could hardly bring that down to twelve seconds, especially if the tub was twice weighed.

Mr. TATE—The tub just goes over and back again; we can team it quicker than we can draw it out of the pit.

Mr. THOS. BELL thought the kick-up and travelling belt were quite capable of taking twice their present quantity.

Mr. BLACKETT said it might be some guide to mention that it was usual with them to change the tub and draw the coals from the bottom of the pit in twenty seconds.

Mr. BELL—What depth?

Mr. BLACKETT—Forty fathoms.

Mr. BELL—What is yours, Mr. Tate?

Mr. TATE—One hundred.

Mr. BLACKETT—I am only speaking of changing and drawing out of the pit—twenty seconds—as against the kick-up.

Mr. C. C. LEACH asked what brought the tub to rest in the kick-up?

Mr. TATE explained (illustrating with a sketch on the blackboard) that the road was "dished" a little.

Mr. BELL said many cages were fitted in the same way without the sneck. The full tub coming in knocked the empty one out.

Mr. A. L. STEAVENSON said Mr. Tate did not debit himself with cost of steam, nor did he give the horse-power required. This information would be useful.

Mr. STRATTON hoped the discussion on this paper would not be closed to-day, but that this paper, and that by Messrs. Forster and Ayton, would be discussed together.

The PRESIDENT—But anything you do to-day will assist the further discussion of the other paper. Don't stop the discussion of this paper for the sake of the other. They would be sure to come together afterwards, and he would suggest that the present discussion be carried as far as possible.

Mr. STRATTON said there was one point, then, which he might mention, which was of interest to those who had belts. How did Mr. Tate deal with stones? Did he run more than one kind of coal at a time? Were the stones loaded into wagons, and how?

Mr. TATE said there were three kinds of coals. Referring to the diagram on the wall, he explained that the peas and duff went out behind; the stones were just teamed by a shoot into wagons.

Mr. STRATTON—By hand?

Mr. TATE—Yes.

Mr. STRATTON said he meant by his question the different kinds of good coal separated.

Mr. TATE said they made only one kind of best. If other separation were desired they could have a middle partition for the best, and run it into a separate wagon.

Mr. BELL said it was rather objectionable to have a separate box and belt. It had been tried at Rainton, and failed. It got mixed at the far end, and got wrong in other ways, and was eventually taken out.

Mr. J. G. WEEKS asked if Mr. Tate anticipated any difficulty in "laying out" when running at such a speed?

Mr. TATE said 1,000 tons a days were being put over the screen at a Durham colliery. If the manager had been present he could have told them something about it. They had an ordinary old-fashioned kick-up, and there was no difficulty in laying out. As soon as a tub was teamed and ran down the spout, the lad at the handle saw if it was dirty, and if so he put a box on. It stayed there till it got to the end, and was laid out in the usual way.

Mr. BELL supposed the belt was running at such a speed that when a tub was on there was an empty space on the belt, and the box would be put on the space represented by the dirty tub.

Mr. TATE—Yes.

Mr. J. G. WEEKS said that was not his experience; it was generally one continuous stream from one end to the other.

Mr. STRATTON said his attention had been drawn to this very point not long ago by a gentleman who had a large belt running a thousand tons a day, and it was, as Mr. Weeks said, a river of coal and no space. It ran uninterruptedly for the half hour he watched it.

Mr. R. L. WEEKS—But we get an opportunity of cleaning the best and small, whereas at the colliery named they have treble nuts and double nuts and have not a chance to clean them.

Mr. BELL thought perhaps the colliery named was a different case, because they had a very wide screen, something like 1½ inch mesh, and not fifty per cent. of the coal went on the belt, the other went through into the common hopper. They had the chance of sending a thousand tons over the belt and cleaning it.

Mr. J. G. WEEKS—Then, there will be only about 500 tons going over the belt?

Mr. BELL—That is what I mean; the other is going through into the common hopper.

Mr. BLACKETT said, over the belts he had in use they cleaned nothing but unscreened, and it was not possible, as far as he could see, to do anything like a thousand tons over a belt. There might be a thousand tons over the kick-up, in the ordinary way, but screen them, and they did not get much more than half that to clean on the belt. When he put up a belt at Kimblesworth—the first they had—he had no idea how much unscreened they would get over the belt, and the very utmost they had been able to do at Kimblesworth was 500 tons, and even that could not be properly done; still, they had no difficulty in cleaning the coals.

Mr. R. L. WEEKS—How many screens had you before you adopted the belt?

Mr. BLACKETT—About eight; and now we have a belt we are able to work with one belt and two screens.

Mr. J. G. WEEKS—What is the length of the belt?

Mr. BLACKETT—90 feet, and 4 feet wide. We have another, 70 feet and 5 feet wide.

Mr. J. G. WEEKS—Do you find the wide width as easily worked as the narrow?

Mr. BLACKETT—Yes. They had a novel way of turning coals over on that belt, by fixing an ordinary ploughshare above the belt in the first instance to turn the heap of coals over, and other ploughshares further along to turn them back. He was uncertain at first as to whether these ploughshares would break much coal, but there was no breakage to any appreciable extent.

Mr. J. G. WEEKS thought they had something of the same kind at Heworth Colliery.

The PRESIDENT—The object desired to be attained by cleaning was a very important one in many collieries in the North, because it affected the question as to whether the coke was to be clean or dirty. That perhaps caused it to be a matter of greater importance than if it was simply a question of quantity. Each gentleman, however, might now prepare himself against the time Mr. Forster's paper came on, and if it was the opinion of the present meeting that the discussion should be adjourned, to come on at the same time as that on Mr. Forster's paper, perhaps some one would propose it.

Mr. BELL said he thought when Mr. Forster's paper was read that gentleman was kind enough to say he would invite the members to visit the colliery. He would respectfully suggest that such visit should take place before the next discussion; it would materially help the discussion, and be of advantage to the Institute.

The SECRETARY stated that the paper would be published in March.

The PRESIDENT thought Mr. Bell's suggestion valuable. He would endeavour to have it carried out if possible.

Mr. TATE said, as far as he was concerned he would be glad to see the members of the Institute, individually or collectively, at East Hetton.

The PRESIDENT asked if it was the wish of the meeting that the discussion on this paper should be adjourned as suggested? As Mr. Tate had been kind enough to give them a challenge, and say he would be glad to see them, they would now have an opportunity of seeing the screens in operation.

Mr. WILLIS thought it would be a pity to formally close the discussion. Let it remain open.

The PRESIDENT—Then it is understood that the discussion stands adjourned.

The SECRETARY—To be taken with that on Messrs. Forster and Ayton's paper?

The PRESIDENT—Yes.

The PRESIDENT said he supposed that most of the members knew, and it was only necessary perhaps for him to make a formal report, that what might be considered a very successful meeting had been held at Sheffield on the 22nd and 23rd of January in connection with the Federation of Institutes, and, in order that they might know a long time in advance, it had been decided that the next Federated meeting would be held in London on the last day of April, but of this due notice would be given.

This concluded the business, and the meeting terminated.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, MARCH 25TH, 1890.

MR. JOHN GERRARD, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

Mr. H. Sykes Witty, Mining Engineer, Denaby Main Colliery, was elected a Member of the Institute, having been previously nominated.

Mr. JOHN NEVIN read a paper "On the Difference between the Seams in the Northern and Southern Parts of the Yorkshire Coal-field as shown in some of the Deeper Sinkings."—(See Vol. I., page 215, of the Proceedings of the Federated Institution of Mining Engineers.)

DISCUSSION ON MR. JOHN NEVIN'S PAPER "ON THE DIFFERENCE BETWEEN THE SEAMS IN THE NORTHERN AND SOUTHERN PARTS OF THE YORKSHIRE COAL-FIELD AS SHOWN IN SOME OF THE DEEPER SINKINGS."

The CHAIRMAN—I think it is the first time since 1874 that a mining engineer has corroborated that which was then stated by Professor Russell at Barnsley with regard to the Middleton Main and the Silkstone. At that time it was debated keenly, and very strong opinions were held by mining engineers that it was wrong. I listened to Mr. Nevin's subscription to Professor Russell's views with interest, and as Mr. Nevin is so well acquainted with the Middleton Main and Silkstone Seams, I think we may take his statement as not having been arrived at without some consideration. The extension of the coal-field is going on not only downwards in various parts, but also towards the east, and if we could have in the discussions upon this paper some information with regard to the Bentley boring which is, I think, the

farthest east at present, and as to the workings near Frystone and Micklefield, it will be very interesting. It is difficult to discuss a paper immediately after hearing it read, but there may be some points fresh in the minds of some. I think Mr. Ingham may have some views upon the question.

Mr. INGHAM—In 1874 I held an exactly opposite opinion to Mr. Russell, as I stated at the time. I have had no absolute proof to induce me to change my opinion. I rather fancy I shall have to change it, but still, I do not know of any continuous working which absolutely proves the case. Until it is absolutely proved I shall hold to the opinion I then expressed.

The CHAIRMAN—I turned to Mr. Ingham as a coalowner working seams closely associated with the Middleton Main and the Silkstone Bed, the Old Hards and the New Hards.

Mr. INGHAM—I believe it is quite possible that the Blocking Coal and the New Hards or the Middleton Main are the same seam of coal which are represented by the Silkstone at Barnsley. There is a dirt parting in the middle of the coal, and I think it is highly probable that is the case. I should not like to lay it down, but still I have that idea. I go more from the roof of the Silkstone Coal and the roof of the New Hards Coal. The two roofs are so similar, and not only that, but they have the cockle shells in them, as the colliers call them, and that is a strong proof that the Silkstone and the New Hards are the same. I think it is highly probable that the lower portion of that seam has been split somewhere, possibly in the Cawthorne district, which I see Mr. Nevin has marked on the map, and that the amount of dirt has enormously increased when it gets forward to Thornhill and Dewsbury. I mean that it begins to split about the position shown on the map, and the amount of dirt when it gets to us has got to be between 40 and 50 yards thick.

The CHAIRMAN—Of course, you have a similar split up in the Silkstone Seam and an intervening band of dirt in the southern district—in the neighbourhood of Grange, west of Rotherham. They work it there divided, and we know that it unites again to the northwards, near Barnsley. Mr. Nash will probably know that.

Mr. NASH—I know that it is split up at Grange, where there is a considerable thickness of dirt between the two beds, but northwards I cannot speak; at Aldwarke it was worse than at Grange.

The CHAIRMAN—I said in the neighbourhood of Barnsley.

Mr. NASH—Practically between Grange and Hoyland Silkstone, which is about the next nearest pit, it is an unproved field; the sinkings at Wombwell prove it almost unworkable. Between there and Grange, there is no place really where it has been proved conclusively to be of sufficient thickness to warrant working. It is so split with dirt between the tops and bottoms, and the tops also have dirt partings come in, that between the two points it is almost considered unworkable; so far as it is at present known I think it is a very uncertain seam throughout the district and one we cannot rely on. We shall have great difficulty in correlating it with any degree of certainty, on account of the difference in section between the same seam at any two points at which it is being worked with any distance between. The thickness of dirt which comes in between the tops and bottoms, even in a couple of miles, is so great that it is almost a matter of impossibility (if you go up to ten miles between the two points) to say with certainty it is the same seam of coal.

Mr. INGHAM—That is so. In one portion of the New Hard Seam, as we call it, at Thornhill, the men were able to turn a four feet rail over, and it was clear, good coal from top to bottom, but within a distance of a mile and a quarter on a straight line that coal has run out until there are two or three partings, and the extreme thickness of good coal is only 8½ inches. It is full of dirt and rubbish. This takes

place between the top of Thornhill and Ossett and Wakefield, in the direction of Roundwood; and, curiously enough, in the new sinking at Roundwood there is found to be a good seam of coal.

Mr. NASH—If we take the same seam over into the Derbyshire district, at Blackwell Colliery, at the A winnings there, what they call the Black Shale occurs—which is the same seam—3 feet 6 inches thick; and at the B winnings, a mile away, there were 9 inches of smut, which was worthless. There was not more than a mile between the two pits, and no throws of any magnitude between them. It proves that whatever part of the district you go into it is a variable and uncertain seam, and one which will be very difficult to correlate in any district on account of its variableness.

Mr. NEVIN—At Dewsbury there is a district where that coal is so thin as to be unworkable, extending in a north-westerly and south-easterly direction—a strip one mile wide and two or three miles long. We do not know how far it goes south-east.

Mr. NASH—At Stanhope Silkstone, as they work gradually towards the east, the dirt between the bed gets so thick that now on the east side they are only working the tops, which are only about 2 feet 6 inches thick.

Mr. ROUTLEDGE—It is a fault that crosses the pit bottom that causes the difference.

Mr. NASH—It is 2 feet 6 inches there.

Mr. ROUTLEDGE—It was 4 feet on the other side of the fault. It was 4 feet going towards Dodworth, and from 2 feet to 2 feet 6 inches on the other side.

Mr. NASH—I understood Mr. Haynes that nowhere had they more than 2 feet 6 inches of good coal. That part of the district may be worked out. Those who had the first pull took the thickest, and those who follow have the thin coal.

Mr. LUPTON—I do not think that the fact of the seam being thick in one place and thin in another is any argument against its continuity. I think you prove its continuity by the strata of rock—the geological horizon in connection with it.

Mr. NEVIN—If you get the beds above and below you conclude the one between is the representative of the Silkstone, though only a few inches thick.

Mr. LUPTON—Yes; it might be only 1 inch thick and yet be the Silkstone Seam.

Mr. INGHAM—If it is only a black smut there must be a seam of coal; but you must have the black smut there.

Mr. LUPTON—You may come to a point where the seam is washed out. You have the roof and the floor and no seam of coal at all. You find the place where the seam should be and there is no black smut at all. Yet you would say this is the horizon of the Black Shale Coal or the Hard Coal.

Mr. INGHAM—I had a most magnificent picture of a wash-out. The river was 100 yards wide and there was a great pile of coal up against each bank, 6 feet thick. A most delightful thing from a geological point of view, but a most horrible nuisance from a collier's point of view.

Mr. NASH—Still you have the measures above and below.

Mr. INGHAM—Yes; we never lost the lead. I remember astonishing a drifter by saying "you will get against a bank very soon, and have to go right up again." He laughed and would not believe it, but he came against the bank and found 6 feet of coal—not lying as usual, but exactly as if it had been heaped up and squeezed down, which was no doubt what had taken place. The water had washed it up on one side into a heap 6 feet thick; and upon getting through that, we found the seam in its perfect condition. That was in the Black Bed.

Mr. NASH—There is a distinct one more than 250 yards wide in the Black Bed of Derbyshire, which has been followed two miles.

Mr. INGHAM—We have followed this a mile and a half.

Mr. NASH—There is no doubt they have a very apt illustration of that in the Parkgate Bed at Aldwarke.

Mr. NEVIN—And in the Barnsley Bed at Thrybergh Hall.

The CHAIRMAN—And at Roundwood. At Aldwarke it is more in the form of a lake.

Mr. NASH—It does not lose the seam altogether, but is thinned down to 8 inches thick.

The CHAIRMAN—I think it is never entirely absent.

Mr. NASH—But altogether there are 800 acres reduced from 4 feet to under a foot. If you take the geological survey as made by Professor Green and other people, with respect to the Parkgate Bed at the Old Sovereign and Higham Pits, there is only a mile and a half distance between the two; yet according to their figures you find a difference of 20 yards in the same bed in the two sinkings.

Mr. INGHAM—In the thickness between?

Mr. NASH—The strata between the two.

Mr. INGHAM—The Parkgate and Silkstone?

Mr. NASH—Yes. If you get that thickness between the two there, then taking 10 miles in the same ratio, you would have great difficulty in saying the bed is the same thing at the two points. There would be perhaps 200 yards difference in the distance they were apart. How could you correlate the two together?

The CHAIRMAN—You would have to take into consideration the thickness of the several strata.

Mr. NASH—But other seams might run in the wedge-shaped piece of strata that came in between the two beds in point, and be taken for either of the beds; the thickness, too, might be similar without its being the same bed of coal.

Mr. LUPTON—Don't you think we should consider in this discussion the mode of formation of the coal-field? How are we to decide what evidence will satisfy us as to the continuity of the seam? No seam of coal continues quite unbroken for many miles, faults intervene, there are wash-outs, thinning-outs, and thickenings. Therefore the continuity of a seam, geologically speaking, depends on our conception of what constitutes identity in coal seams, and, to my mind, this involves some theory as to the method in which coal seams are formed and of the deposition of the intermediate strata.

The CHAIRMAN—That opens out a new point as to geological time. Seams of coal deposited at the same point of geological time are the same. That is shortly what you mean?

Mr. LUPTON—I put it as a query. I have not gone into the question sufficiently to have an opinion upon it.

Mr. TURNBULL—Cannot the extra thickness of dirt between the two seams be accounted for by the coal seams being formed in a basin, and the rain bringing down the mud from the higher land? There would be greater deposits at the edge of the coal basin and in the middle less, and at one point there may be no deposit between the coal seams and at another a greater thickness.

Mr. T. W. H. MITCHELL—But the Silkstone is thick at the outcrop and thin further in-bye, where you would think the dirt would be thinner.

Mr. NASH—So far as to its being thinner, the Silkstone is always found thickest and best near the outcrop in the neighbourhood of Silkstone.

Mr. TURNBULL—I was not speaking of the thickness of the seam, but of the strata between the seams.

Mr. LUPTON—With regard to the Beeston Coal. I am not quite prepared to admit that the Beeston Coal found in the neighbourhood of Leeds is a second class coal.

Some portions of it may be inferior to some portions of some other seam, but that the seam as a whole in the neighbourhood of Leeds, from 4 to 6 feet thick, is a second class seam, I am not prepared to admit. There is some of the best house coal in the seam which can possibly be got, and also steam and gas coal.

Mr. INGHAM—I have perhaps the deepest sinking to the Beeston Bed in our part of the world, I have sunk through it to the Black Bed. I found the Beeston Bed about 20 yards thick. That sounds curious, but it is undoubtedly the Beeston Bed, which is spread out with several yards of muck between the component seams, and the thickest bit of coal I have got is 29 inches. There are several seams which are three or four inches thick. These seams at Beeston are all close together and form one seam of coal.

Mr. ROUTLEDGE—At Garforth the Beeston Bed has 5 feet of coal, 3 feet of which is best and 2 feet of seconds, which is splendid coal. It runs to 5 feet 6 inches at some places.

Mr. NASH—There is nothing to be argued from the quality of the coal. The seam varies so much in a short distance that we cannot argue from that that it is not the same bed. In a very short distance the Silkstone Seam varies as much in quality as in thickness.

The CHAIRMAN—The same applies to the Barnsley Seam with regard to its varying thickness and quality.

Mr. LUPTON—I should like Mr. Nevin to include in his paper a reference to the Millstone Grit Coal.

Mr. NEVIN—I do not know anything about that. Have you a place where the Millstone Grit Coal was worked profitably?

Mr. LUPTON—I have in my mind a place where I have seen it worked in the Millstone Grit, from 3 feet to 5 feet thick. It is twenty years since I saw the workings.

Mr. NEVIN—It is at Tanhill, near Bowes; I believe it is working now.

Mr. LUPTON—It is in the Millstone Grit, which extends all over and caps the hills of Yorkshire.

Mr. INGHAM—You can find that seam in the hills 6 miles above Masham—there are old coal workings plain enough, and colliers' houses. Distinctly there has been a thin seam worked in the Millstone Grit—that is, the Millstone Grit proper is above the horizon where the coal was worked.

Mr. NEVIN—I believe it has been worked all the way from Silkstone to Chatsworth.

Mr. INGHAM—I should say it was the same coal as the Halifax Soft or Hard Bed.

Mr. LUPTON—No; it is a long way below the Halifax Coal.

Mr. NEVIN—As to the difference between the various beds of coal, they vary very much. You will have cases where beds 100 yards apart will run parallel for miles, and the coal seams between them will vary very much up and down, or two coals will run together and run apart again. We have a case in the section—what we call the Old Hards Coal. At Mr. Ingham's collieries, with two pits 150 yards apart, they had to drift from one to the other in this coal, and, instead of meeting, found themselves six or seven yards apart, having started in a different coal in each pit. Then some coals will carry the same roof for miles and miles; the Flockton Thick does so almost all over the county. Taking the New Hards and the Middleton Main—in some cases you have sandstone rock right down to the coal, and in others a black scale, such as you get with the Silkstone. I do not know anything that will prove the continuity of the seam except sinking and driving in it. We cannot say what it is, and what it is not, until we have sunk to it in the debateable strip where the

question lies at present. As to the Beeston Coal, I think it only holds a second class place commercially at present, but I say if it continues in the same good state, it is east of Leeds, towards the south it will be one of the most valuable seams of the coal-field. At Manston and that country it is a very good seam, but towards the outcrop it gets comparatively worthless. The question is, will it continue south in one good seam, or in several small ones, as Mr. Ingham has it in his pits and at the Mirfield Colliery?

Mr. ROUTLEDGE—As you go to the south-west it gets better, but towards the east and under the limestone it gets worse.

Mr. INGHAM—Is that north of Leeds?

Mr. ROUTLEDGE—Yes.

Mr. NEVIN—I shall be glad if gentlemen from South Yorkshire will help me to continue the sections downwards. If any gentleman working the Ganister Coal could continue this section downwards it would be of value to the Institute.

Mr. LUPTON—Mr. Nevin has got on the wall a section of the Northumberland Coal-field; but he has not said anything about it in his paper.

Mr. NEVIN—I simply came across that section in a paper read before the North of England Institute in 1860. I bought it as a curiosity and have not gone into it. When we have a difficulty in correlating the seams of our own coal-field I do not know how we can draw a hard and fast line, between those of Northumberland and our own, with 60 miles between.

Mr. NASH—Personally I am much obliged to Mr. Nevin for the great trouble he has gone to in connection with this paper. It is a very able one, and if we could get it in print it could be discussed with advantage by all of us. We are all interested in the different coal seams and cannot know too much about them. If we get an expression of opinion from everyone with respect to the seams in their own districts we can, in the discussion, form some more definite idea as to the proper position of the same seam in the two districts of South and West Yorkshire. I have pleasure in proposing that the best thanks of the Institute be given to Mr. Nevin for his paper, and that we have it printed in the Transactions.

Mr. LUPTON—I have great pleasure in seconding that. I think it is the kind of paper likely to give rise to prolonged and enthusiastic discussion, and discussion of great value. I think we are much indebted to Mr. Nevin for bringing forward so suggestive a paper.

The motion was carried.

Mr. NEVIN—I am much obliged for the vote of thanks. I do not think there is much in the paper, but I hope the discussion will be of value to all of us when it comes on.

THE ISSUE OF THE TRANSACTIONS.

A conversation took place as to the issue of the Transactions, the Chairman pointing out that the absence of the Transactions containing papers read in December last prevented an important discussion.

Mr. J. E. CHAMBERS moved "That this meeting regrets that it has been found impossible to supply members with copies of the papers read three months ago at the meeting of this Institute, the absence of which prevents their adequate discussion, and expresses the hope that the Publishing Committee will try to expedite their issue, and thus facilitate business in the future."

Mr. POLLARD seconded the motion, which was carried.

Mr. CHAMBERS moved, and Mr. NASH seconded, a vote of thanks to the Chairman, which was acknowledged.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE INSTITUTE ROOMS, BARNSLEY, APRIL 16TH, 1890.

MR. JOHN GERRARD, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated:—

Mr. Frank Kestéven, Mineral Surveyor, Monckton Main Colliery, Barnsley.
Mr. Francis Ed. Middleton, Mineral Surveyor, Lofthouse, near Wakefield.
Mr. William Pattison, Colliery Manager, Morley Main Colliery, Leeds.
Mr. R. H. Longbotham, Mining Engineer, Wakefield.
Mr. G. H. Stones, Mining Student, Denaby Main Colliery, near Rotherham.

In consequence of the small attendance of members present, it was agreed to adjourn the meeting to a future date.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

ANNUAL MEETING,

HELD AT THE INSTITUTE ROOMS, BARNSLEY, AUGUST 20TH, 1890.

MR. T. W. EMBLETON, PAST-PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The CHAIRMAN—We shall require Scrutineers to count the votes for officers and Council.

Mr. J. GERRARD proposed, and Mr. J. MITCHELL seconded, that Mr. T. E. W. Saint and Mr. W. E. Teale be Scrutineers, and the motion was carried unanimously.

The following gentlemen were elected Members of the Institute, having been previously nominated :—

Mr. Edgar Hall, Mining Student, Wharncliffe Silkstone Colliery, Barnsley.

Mr. Lancelot Dobinson, Colliery Manager, Park Hill Colliery, Wakefield.

The SECRETARY reported that Mr. Thomas Carrington had offered to present to the Institute a steel engraving of the late Mr. J. T. Woodhouse, of Derby (first President of the Institute), and that the Council had unanimously agreed to accept the same and accord a vote of thanks to Mr. Carrington for his offer.

The SECRETARY read the Council's Annual Report as follows :—

THE COUNCIL'S ANNUAL REPORT.

The Council, in presenting their Annual Report for the year ending June, 1890, to the members of the Institute, have to state that the following papers have been read:—

"On an Outburst of Gas at Monk Bretton Colliery," by Mr. J. L. Marshall.

"On an Outburst of Gas at Houghton Main Colliery," by Mr. J. Jarratt.

"On an Outburst of Gas in the Haigh Moor Seam at Whitwood Collieries," by Mr. W. G. Jackson.

"On Overwinding and its Prevention," communicated by Mr. A. Bertram.

"On a Patent Apparatus, Indicator, and Valves for the Automatic Prevention of Overwinding at Mines," by Mr. C. H. Cobbold.

"Notes on the 'Medium Fan,'" by Professor Lupton.

"On the Geology of the Southern Portion of the Yorkshire Coal-field," by Mr. R. Russell, C.E., F.G.S.

"On Coal-getting by Machinery," by Mr. G. Blake Walker, F.G.S.

"On the Distribution of Electrical Energy over Extended Areas in Mines," by Mr. A. T. Snell.

"On the Difference between the Seams in the Northern and Southern Parts of the Yorkshire Coal-field as shown in some of the Deeper Sinkings," by Mr. John Nevin.

"On the Stauss System of Colliery Cage Props," communicated by Mr. Edmund B. Clarke.

"On the Action of Tidal Streams on Metals," by Mr. Thomas Andrews, F.R.S.

The following subjects have also been discussed:—

"The Federation of the Mining Institutes."

Messrs. Jackson, Jarratt, and Marshall's papers "On Outbursts of Gas."

Mr. John Nevins's paper "On the Difference between the Seams in the Northern and Southern Parts of the Yorkshire Coal-field as shown in some of the Deeper Sinkings."

Professor Lupton's paper "On the 'Medium Fan.'"

The number of members on the books of the Institute at the end of the year was 3 Life Members, 18 Honorary Members, and 153 Ordinary Members. This is an increase of 7 in the number of Ordinary Members.

The Council are glad to report that the number of members in arrear with their subscriptions is less this year than last, although the amount owing is slightly more; this is in consequence of the increased amount of the subscription due from each member, but showing a continuance in the decrease of members in arrear as mentioned in last year's report.

The accounts appear to be satisfactory, inasmuch as there is no balance due to the Treasurer.

The cost of the meeting of the Federated Institutes in Sheffield has somewhat increased the liabilities and expenses.

At the last annual meeting it was resolved to join the Federated Institution, and the necessary steps have therefore been taken to carry out the wishes of the members.

The first meeting of the Federated Institution was held at Sheffield, on January 22nd, under the presidency of Mr. John Marley, President of the North of England Institute and of the Federated Institution, and a very successful gathering resulted, the papers read being of considerable interest and ability. The Council take this opportunity of according their thanks to those owners and managers who gave facilities for the members of the Federated Institution visiting their works.

The Council are glad to report an increase in the number of papers read during the past year, though this number falls far short of what is required for the successful carrying on of the Institute.

The first three papers dealt with the very important feature in mining of sudden outbursts of gas under the water-bearing strata, the frequency and importance of which have often been the subject of discussion at the meetings, and it is hoped these papers may be an incentive to members to put on record their experience under similar circumstances, however small the occurrence may be.

The two papers on appliances for the prevention of over-winding are well worth the consideration of the members.

A paper was read upon the "Medium Fan," and the principle of measuring air for the purpose of recording ventilation.

The papers on the geology of the Yorkshire coal-field are now most interesting, as sinkings are extending eastward, and should tend to further discussion and information.

The question of mechanical appliances for working coal underground has also been ably treated in papers read upon the subject.

Nothing has appeared during the past year to alter the opinion of the Council as expressed in last year's report as to the danger of sparking in the use of electricity underground, although the importance of this question has been ably dealt with in a paper read before the Institute. The Council draw the special attention of the members to the importance of this subject, as affording a large field for discussion as to the best means of applying a power undoubtedly of great use in affording improved facilities for the working of collieries, especially for underground haulage, coal-getting, pumping, lighting, and other means of economically working the coal seams.

Another subject brought before the Institute was the electrical action of tidal streams upon metals of various kinds, and the damage occasioned thereby. The result of this electrical action of some kinds of water upon metals is a most important subject, and should have the careful attention of the members.

The report of the Joint Committee appointed to experiment upon fans has not yet been completed, owing to the Committee being desirous of carrying out further experiments in order to present to the Institute a most exhaustive and finished report.

The Council would remind the members that papers read before the other Federated Institutes, and printed in the Transactions issued to the members of this Institute, are open for discussion at the meetings. An intimation to the Secretary would ensure the subject being inserted in the agenda.

In conclusion, the Council trust that members will support the Institute in the coming year with papers on various subjects, for the purpose of affording information and promoting discussion not only on scientific subjects, but especially with regard to matters of everyday occurrence in connection with the working of collieries; and they also draw the attention of the members to the importance of

attending the meetings in order that more general interest may be engendered the discussions, and wider experience presented to the members as a body.

The CHAIRMAN—Gentlemen, I do not think that it is necessary for me to m any remarks on the report. It embraces in a concise form the whole of the info tion laid before the Institute in the past year in the shape of papers and discus I move, therefore, that it be adopted.

Mr. R. CARTER—I have listened with great pleasure to the reading of report, and have additional pleasure in seconding the proposition that it be rec and adopted.

The report was unanimously adopted.

The SECRETARY read the statement of Accounts for the past year.

THE TREASURER (T. W. H. MITCHELL) IN ACCOUNT WITH THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS, 1889–90.

Dr.

Date			£	s.	d.
1889.					
July 1.	—To Balance at Bankers		106	5	0
1890.					
June 30.	—To Members' Subscriptions		225	9	0
,,	,, Donations:—				
	E. T. Ingham, Esq. ...	10 0 0			
	H. Garland, Esq. ...	5 0 0			
			15	0	0
,,	,, Sale of Dinner Tickets		8	5	0
,,	,, ,, Federated Institution Dinner Tickets		47	15	0
,,	,, ,, Transactions		0	12	6
,,	,, Members' portion of Wine Account at the Federated Institution Dinner		4	7	0
,,	,, Balance of 'Bus Fares in connection with visit to Manchester Ship Canal ..		1	3	0
,,	,, Bank Interest		2	4	3
			£411	0	9

Audited and found correct, { GEO. J. KELL. / A. B. SOUTHALL. }

Cr.

Date		£	s.	d.
1889.				
July 1.	—By Balance due to Treasurer...	8	12	8
1890.				
June 30.	—By R. E. Griffiths	95	0	0
,,	,, Royal Victoria Hotel Co., Sheffield, Federated Institution Dinner and Meeting	66	0	0
,,	,, Pawson & Brailsford, Printing in connection with Federated Institution Dinner and Meeting	9	1	6
,,	,, James Fox & Son, Annual Dinner ...	14	13	0
,,	,, Reporter	16	5	0
,,	,, Secretary's Salary	25	0	0
,,	,, ,, Expenses	9	19	8
,,	,, Engineer's Expenses in conducting Joint Fan Experiments	4	8	0
,,	,, Federated Institution, being a call of 3s. 9d. per member on 153 members of the Midland Institute	28	13	9
,,	,, Rent of Room (½ year)	6	0	0
,,	,, Fire Insurance Premium	0	15	9
,,	,, Jos. Frost, for conveying members from Woodlesford Station to Bower's Colliery in connection with Federated Meeting	1	12	0
,,	,, W. Woodcock	0	14	6
,,	,, Hire of Rooms for Meetings in Leeds and Sheffield	1	16	0
,,	,, Barnsley Gas Co.	0	4	4
,,	,, Stamps, Telegrams, Post Cards, and Sundries	17	0	4
,,	,, Balance at Bankers	101	16	10
,,	,, Room Cleaning	0	5	0
,,	,, Cash in Treasurer's hands	3	2	5
		£411	0	9

Midland Institute of Mining, Civil, and Mechanical Engineers.

General Statement, 1889–90.

Liabilities.

1890.		£	s.	d.
June 30.—To	R. E. Griffiths	27	0	0
„	„ Reporter	10	15	0
„	„ Federated Institution, being a call of 11s. 3d. per member on 153 members of the Midland Institute	86	1	3
„	„ Barnsley Gas Co.	0	1	0
„	„ Rent of Room (½ year)	6	0	0
„	„ M. Lowrance & Son	0	7	6
„	„ Balance, being Capital	352	3	6
		£482	8	3

Assets.

1890.		£	s.	d.
June 30.—By	Cash in Bank	101	16	10
„	„ „ Treasurer's hands...	3	2	5
„	„ Arrears of Subscriptions	35	14	0
„	„ Estimated Value of Instruments for Fan Experiments (½ portion)	16	0	0
„	„ Value of Transactions, 6,515 at 1s. per copy	325	15	0
		£482	8	3

Audited and found correct, { Geo. J. Kell. / A. B. Southall.

The CHAIRMAN—The accounts are different to our usual accounts, owing to the Federation of the Institutes. I think the finances are in a very sound condition—even more so than last year or the year before. As to the amount of the arrears of subscription being larger is accounted for by the increased amount of subscriptions, so that if ten members were in arrear in the former subscription. and ten were in arrear on the present subscription, the amount in arrear would be greater.

Mr. SOUTHALL—That is so. I might say that as Auditors we thought to reduce the value of these Transactions would not interfere with the financial position of the Institute. It is my impression that having been put on both sides of the balance sheet, if they were reduced, it would not alter its financial position. Referring to last year's account, the capital is £378, the estimated value of the Transactions £324; to reduce both can make no difference.

The CHAIRMAN—In that estimate you include nothing—not even our library?

Mr. SOUTHALL—No. I might say we found the accounts kept in good order, and we had no difficulty in getting any information we wanted. I think it is only just to the Secretary we should say that once a year at any rate.

Mr. J. JARRATT moved the adoption of the accounts.

Mr. J. NEVIN—I beg to second that. I think they are very satisfactory. The Institute every year is getting to a sounder position, very different to that of ten years ago.

The accounts were unanimously adopted.

THE ISSUE OF THE TRANSACTIONS.

The SECRETARY read the following letter from Professor Lebour, Secretary of the Federated Institution of Mining Engineers, with reference to the delay in publishing the Transactions:—

Federated Institution of Mining Engineers,
19th August, 1890.

Dear Sir,—I am in receipt of your telegram (this morning only, as I was away when it arrived yesterday), and can only say in answer to it that I regret the delay as much as, and probably more, than anyone, but so long as authors will cause delays, delays there will be. At present two plates cannot be printed off, because the lettering, which the authors alone can provide, is incomplete, otherwise all has been ready some time, except the "Coal in Kent" paper, which has not yet reached me, and which I am, of course, not including in the present part.

I fought hard against the notion that parts *could* be got out so rapidly as was proposed, and my opinion is, I am sorry to say, justified.—Yours faithfully,

G. A. LEBOUR.

T. W. H. Mitchell, Esq.

The CHAIRMAN—The Council have directed that Professor Lebour be written to on this subject, urging that such unreasonable delay be avoided in future.

The meeting endorsed the action of the Council.

ELECTION OF OFFICERS.

The Scrutineers reported the results of the election of officers as follows :—

PRESIDENT.

J. Mitchell, Esq., M.I.C.E., F.G.S., Regent Street, Barnsley.

VICE-PRESIDENTS.

W. E. Garforth, Esq., West Riding Colliery, Normanton.
J. Gerrard, Esq., H.M. Inspector of Mines, Wakefield.
J. Nevin, Esq., Dunbottle House, Mirfield, Normanton.

COUNCIL.

E. Bainbridge, Esq., Nunnery Colliery Offices, Sheffield.

W. Hy. Chambers, Esq., Denaby Main Colliery, Rotherham.

M. Hall, Esq, Lofthouse Colliery, Wakefield.

S. H. Hedley, Esq,, Bank Chambers, Wakefield.

J. Longbotham, Esq., Barrow Collieries, Barnsley.

H. B. Nash, Esq., Clarke's Old Silkstone Colliery, Barnsley.

A. B. Southall, Esq., Monckton Main Colliery, Barnsley.

A. Tyas, Esq., Warren House, Sheffield Road, Barnsley.

SECRETARY AND TREASURER.

T. W. H. Mitchell, Esq., Eldon Street, Barnsley.

The CHAIRMAN—I congratulate you, Mr. Mitchell, on your election. I think you have for a long time deserved to be President; and now that the time has come when you are President, I wish you a very prosperous year during your presidency.

Mr. JOS. MITCHELL—I feel deeply grateful to you for the kind remarks you have been good enough to make. I also feel deeply the honour the members have done me in electing me President for the ensuing year. I hope I may be able to follow the good example set by you and the other Past-Presidents who have held that chair. I shall do my best to fulfil the duties of the chair ; although I fear I shall not be able to do it in the same manner that it has been previously, but there will be nothing lacking so far as my will is concerned. It will depend on the Council and members generally to make the year of my office a success, because no matter who is President it rests more particularly on the individual members whether the Institute is to succeed and be a successful Institute for the guidance of others in matters connected with mining and colliery work in this district. I thank the members, present and absent, for electing me to the office of President.

The CHAIRMAN—I think I have reason to congratulate the three Vice-Presidents, Messrs. Gerrard, Garforth, and Nevin. I feel sure they will fill the posts assigned to them to the satisfaction of the Institute, and give their best assistance to the President in managing the affairs of the Institute.

Mr. NEVIN—I am much obliged to the Chairman for what he has said about us. So far as I am concerned I shall be glad to do anything I possibly can for the welfare of the Institute.

The CHAIRMAN—I may give the same congratulations to the Council, because I believe it is a very good thing for President and Vice-Presidents when the Council

give them their cordial assistance in the work of the Institute; whatever arises they will be able to conduct the business of the Institute in a right and proper manner, and will give their assistance not only to the President but to the Vice-Presidents.

Mr. SOUTHALL—Being an old member of the Council, I will let the younger members respond.

Mr. W. HENRY CHAMBERS—I cannot do better than endorse all that Mr. Southall has said. I have had the honour of being a member of the Council before. I was sorry I was not able to attend a sufficient number of meetings to qualify me to continue in the office. I shall do all I can to put in attendances this year, so as to give any assistance that I may to the operations of the Council.

The CHAIRMAN—I am sure we all ought to be delighted with the sentiments expressed by the President, Vice-President, and Council. They intend to carry on the business of the Institute in a proper way, and we shall have a much more prosperous year than the last.

Mr. J. JARRATT—I beg to propose a vote of thanks to the retiring President for the work that he has done, and the way in which he has presided over the meetings in the past year.

Mr. A. M. CHAMBERS—I am very glad indeed to second that resolution. I do not know anybody who has done more for furthering the scientific working of collieries in this district than Mr. C. E. Rhodes, our late President. He has given any amount of time and attention to matters of immense importance to us, especially with regard to the experiments that he made with safety-lamps. I think he deserves far more than a formal vote of thanks for the service he has done in his two years' office as President. I do not know any one who is more willing to place information that he obtains, and any researches that he has been successful in, at the disposal, not only of the Institute, but of all persons connected with colliery management, than Mr. Rhodes. I hope that he will continue to take the same interest in the Institute and its affairs as he has done in the past, and we shall have in him a very powerful member of the small band of Past-Presidents we possess.

Mr. R. CARTER—It affords me great pleasure to be here to-day to renew old acquaintances, and on many other grounds. To see so many old friends is a pleasure I realise with more than ordinary satisfaction. I am very glad to have the opportunity of supporting the proposition just now submitted, and seconded by our former President, Mr. A. M. Chambers. I feel more than ordinary gratification in adding my testimony to the very great, most valuable, and effective services rendered to this Institute during the two years' presidency of Mr. C. E. Rhodes. His term of office was marked by much activity and corresponding usefulness in advancing the interests of this Institute through the many channels in which its influence is made to be felt in all departments of mining engineering. His personal services and the zeal which he imported into his office we all well remember. I regret his not being present to-day at this meeting; but I hope before the ceremonies of the day have been quite completed, in those important parts of our proceedings which have yet to come, we may have the satisfaction and pleasure of seeing him amongst us. I have known Mr. Rhodes many years, and have been an admirer of his industry and application, his shrewd common sense, and his great achievements in the several departments of mining and mechanical engineering. It is with great pleasure I support the expression of thanks which I think will be universally accorded to Mr. Rhodes. Every member of the Institute will feel we are doing but scant justice in passing this resolution which has been so well merited by the way in which he has filled the duties of this most important office.

The CHAIRMAN—I agree with what has been said with respect to Mr. Rhodes. I have noticed his great assiduity in endeavouring to bring all the facts that he has ascertained clearly before the Institute. In those experiments with safety-lamps he took means to show the members of the Institute that certain lamps which were said to be safe were not safe. One member of the Institute had such confidence in the Stephenson lamp that he absolutely could not believe that it could be exploded until he saw it with his own eyes. Such facts as these spread over the country have considerable use in informing people as to what lamp is safe and what is unsafe. I will not put this resolution in the ordinary way, but that it be carried by acclamation.

The resolution was carried with hearty acclamation.

Mr. SOUTHALL—There is one proposition I wish to make, that is—a vote of thanks to the Chairman. I am sure you will all agree with me that in taking the chair he has filled an office he has filled many times before to the satisfaction of all present. I hope we shall see him many times in the future when he comes to these meetings occupying that chair.

Mr. G. J. BURNLEY—I have great pleasure in seconding that resolution. I hope Mr. Embleton will be spared many years to occupy the position that he does now.

The resolution was carried by acclamation.

The CHAIRMAN—I am much obliged to you for the way in which you have expressed yourselves with respect to me. I do not think you should expect me to attend this Institute many more years. I am almost too old to attend this Institute or any other, but I am much obliged to you for your kind expressions.

The annual dinner was afterwards held at the King's Head Hotel.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

SPECIAL GENERAL MEETING,

THURSDAY, JUNE 5TH, 1890.

MR. JNO. WILLIAMSON, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read, confirmed, and signed.

Letters of apology were read from Mr. W. Fairley and Mr. W. H. Glennie.

Mr. Edward Lloyd Jones and Mr. James Shenton, having been duly nominated, were unanimously elected Members.

The SECRETARY then read the rules as revised at the last meeting.

Mr. WHITEHOUSE moved, and Mr. WARDLE seconded—"That the altered rules, as now read, be adopted."

The motion was carried unanimously.

Mr. C. W. SUMMERSKILL exhibited and described the "Patent Adjustable Automatic Fire Alarm and Heat Indicator."

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT MASON COLLEGE, BIRMINGHAM, THURSDAY, AUGUST 7TH, 1890.

MR. A. SOPWITH IN THE CHAIR.

The minutes of the last meeting were read, confirmed, and signed.

Upon the motion of Mr. H. W. HUGHES, seconded by Mr. WARDLE, it was resolved—" That the rules, as amended and adopted at the last meeting, be printed and sent out to the members."

In reply to a question by a Member, the CHAIRMAN said that the increased subscription (£1 11s. 6d.) would commence from the 1st of January next.

The CHAIRMAN then called upon Mr. H. W. Hughes to read his paper upon " Safety-Lamps."

NOTES ON SAFETY-LAMPS.

By Herbert W. Hughes, F.G.S., Assoc. M. Inst. C.E.,
Associate of the Royal School of Mines.

It seems rather late in the day to refer to the effect that the passing of the Coal Mines Act of 1887 had on modifying the types of safety-lamps used in collieries. The regulations then made, practically prohibited the use of the old unbonneted forms which had existed for so long and done such good service. It became necessary to select from the numerous new designs thrown on the market, some lamp which gave good results under the conditions existing in mines. At this point it will be best to state, that in the present paper no attempt is made to classify the lamps under the head of safety, so far as resisting explosive currents of highest velocity is concerned. Only such lamps were selected for experiment, as were well known to fulfil this condition under all ordinary circumstances. What has been done was to give lamps into the hands of deputies, who noted their behaviour in the presence of gas, their illuminating power as compared with one another, and the light they gave after burning for some hours underground.

Something more is needed in a safety-lamp, than the fact that it is safe in explosive currents of high velocity. Experiments at the surface are carried on with lamps perfectly clean, the experimenters' hands are in the same condition, the currents to which they are exposed are of high velocity and composed of fresh air mixed with gas, while coal dust is conspicuous by its absence. Underground, the conditions are essentially different, this being especially the case in thick coal mining. No matter how high the velocity may be in the gate-roads, when the current passes into the openings, measuring 30 feet wide by 20 feet high, and not only into one chamber but into many, it practically appears to be stagnant, although the same volume is actually passing through. Powder smoke hangs about, and in addition we are often troubled with carbonic acid gas, resulting from the preliminary stages of spontaneous combustion. From the nature of his avocation, the miner's hands are by no means clean; he handles lamps in rather a rough and ready style, with the result that dirt and grease is transferred to them. Coal dust also clogs up the inlet holes and gauze. It therefore follows that the behaviour of some of the modern types of safety-lamps, after they have been some hours underground and in the return air-current, is scarcely what one would desire. This, however, is what one might expect from the very nature of the conditions which the lamps are constructed to withstand. In order to be safe in the highest velocity of air-currents, they must be enclosed in either one or two shields, and the inlet area for feed air must be reduced to the smallest dimensions. So long as they are clean and remain in a strong current, the requisite amount of air for proper combustion is delivered to the flame, but when the velocity is small and the lamp gets dirty, or is used in impure currents, the light given is of a very inferior character. Experience in our collieries. has proved that several of the lamps which have given excellent results when tested on the surface, are practically failures when they are used under the ordinary conditions existing underground.

Nine distinct types have been on trial for over a year, and in many instances several modifications of the same lamp have been experimented with. It is not proposed to deal minutely with every pattern, or even every lamp, but to briefly point out the prominent characteristics of a few, and state the results obtained.

Hepplewhite-Gray.—The report of the Royal Commission on Accidents in Mines first drew attention to the original form of this type. As the lamp then reported on so favourably is so different in construction to its modern representative the drawing accompanying the report referred to is reproduced (Fig. 1, Plate I.) with a view of clearly showing the successive developments which have taken place. Its chief peculiarity (and in which it differs from all modern safety-lamps) is the admission of the feed air from the top, down four tubes, and then through an annular chamber, *b*, situated immediately above the oil vessel. It will be noticed that it is impossible for a current to rush directly down the inlet tubes, as they are protected by the projecting top of the lamp. The only gauze employed is that covering the outlet, *c*, and the annular inlet chamber. The first improvement, consisted in introducing a gauze cylinder above the glass, which now took a conical form, and adding a cone to the discharge orifice. The importance of the latter cannot be over-estimated. M. Marsaut* has satisfactorily proved, that the gases resulting from combustion play an important part in preventing internal explosions in a lamp, and that it may be desirable to restrict their discharge. The outlet arrangements of most lamps are hap-hazard, and bear no relative proportion to the area of inlet. With the discharge regulated in such a manner, the top of the gauze is kept in a bath of carbonic acid gas, and should internal explosions occur, gas will not continue burning in the lamp. The advantage of the gauze in place of the brass chimney will be readily admitted, as M. Marsaut's experiments proved that there must be a certain relation between the volume contained in a lamp and the surface of gauze.† In the earlier modifications, a horizontal diaphragm ring was placed outside and above the glass, but this was soon done away with, as it was found to obstruct the light. Sliding shutters were also placed at the lower end of two tubes, by which means the feed air could either be taken from the top, or the base of tubes, an improvement properly appreciated by anyone regularly testing for gas.

In the form described above, the lamp was first tried in the colliery under the writer's charge, and in an address made in July, 1889, he stated that as a fireman's lamp it was probably superior to all others; it readily indicated small percentages of gas and gave a very good light, but it had a most unfortunate way of being suddenly extinguished when brought out of a still current into a rapid one.‡ This was specially noticeable, when passing through air-doors. Mr. James Ashworth's attention was drawn to these remarks, and he very kindly sent the writer a series of different designs of this type, which were experimented with, and from the results obtained the form shown in Fig. 3, Plate I., was adopted. At first sight this appears similar to the old design, but it contains a number of alterations, each trivial in itself, but which in combination, give a far superior lamp to the one originally in use.

Before alluding to the different modifications tried, it will perhaps be best to describe the form finally adopted. In place of the four inlet tubes, three only are used, as will be seen from Fig. 4, Plate I., which is a section on line A B, Fig. 3. The third tube is considerably broader than the others, and acts as a reflector. The shield-plate *a* in the hood, is made of such a size as to completely cover the inlet holes. This is an important point, as it was found that in the lamps which were extinguished in such an unaccountable manner, this condition was not fulfilled. The height of the outlet cone, must be such as to just reach to the level of the shield-plate, when it then occupies a position intermediate between the two horizontal rings of holes, *b* *b*[1], which are placed in the hood for the products of combustion to

* "Miners' Safety-Lamps," by J. B. Marsaut. Translation by J. A. Verner and W. H. Routledge, Chesterfield and Derbyshire Institute of Engineers, Vol. XII., p. 193.
† *Ibid.*, p. 86.
‡ President's Address, Journal of the British Society of Mining Students, 1889-90, Vol. XII., p. 17.

èscape by. In the top crown of the lamp is put a circular row of holes of the same diameter as those in the shield rim; these being covered by a thin sheet brass plate $1\frac{3}{8}$ inches diameter. To stiffen the covering plate, it is crimped in three places, the crimped parts touching the crown as shown at *c*. These improvements remove the defect of the light being suddenly extinguished from no apparent cause. The same results are obtained with the form of hood shown in Fig. 5; here the outlet cone and inlet tubes are covered by a piece of brass bent into the shape illustrated. One hole, $\frac{3}{8}$ inch in diameter, serves for the escape of the products of combustion, this being protected from direct currents, by a piece of sheet brass crimped as before-mentioned. This shape of hood scarcely appears of such a safe character as the former one, but a large number of lamps have been constructed to this design. Another improvement, which facilitates cleaning, is that the ring securing the glass in position is screwed on to the vertical plate forming the air inlet chamber (*d*, Fig. 3) instead of to the frame of the lamp. It follows from this, that when the lower gauze ring is unscrewed, all the inside parts of the lamp at once fall out.

Fig. 2 shows a form very similar to the one just described, except that the outlet holes in crown and the crimped plate above are absent. The height of glass was increased, and gauze diminished in proportion. In the case of internal explosions, the glass of a lamp confines the gases there, and acts really like a cannon; and for this cause it was deemed advisable to keep to the standard height.

Heating of the inlet air seems to make a lamp burn better where carbonic acid gas is present, so to obtain this result in the lamp under notice, a thin copper cone (Fig. 6) is attached to the ring securing the glass in position. Being situated near the flame, this naturally gets hot, and so warms the inlet air which passes directly beneath it. It cannot definitely be said, whether this device really accomplishes the purpose for which it is applied; its action is too delicate for direct observation.

In the lamp of latest design, the portion of oil vessel supporting wick tube has been lowered, but the wick tube itself has been lengthened, so that the flame is only slightly lower than in the old types. The breadth of the wick has been increased, and now stands at $\frac{9}{16}$ inch full.

The numerous small improvements—which may not separately seem of much importance, but which, in conjunction, materially affect the practical working—have increased the high opinion which the writer formerly held of this lamp, and certainly make the design of to-day superior to the one of last year. Taking first its lighting capacity. Under ordinary conditions, it undoubtedly gives more *useful* illumination than any other lamp. Photometric tests conducted at the surface are misleading, for the same reasons as were referred to when dealing with velocity trials. In addition, one other fact must be pointed out. With the photometer, either when testing against another lamp, or against a standard candle, the two articles are placed on the same level, and it is the horizontal rays, or those that are nearly so, which reach the screen and decide the result. Colliers require light to be thrown in all directions, especially upwards, and hence naked lights are often used under conditions which may at any time become dangerous. They are not actually unsafe, but no one can say whether they may become so. It was stated at the inquiry on the Llanerch explosion, by several of the miners who gave evidence, that they preferred to take the risk of working with naked lights, as in their opinion, if safety-lamps were used, accidents from fall of roof and sides would more than compensate for the additional security obtained from explosions. All ordinary shielded lamps suffer from the great disadvantage, of giving practically no illumination on the roof. Their shields are necessarily of larger diameter than the glass and really act like a shade, preventing any light striking upwards. The conical glass of the Hepplewhite-Gray, performs just the contrary action, as it

deflects the light towards the roof, and as the shield above is of smaller diameter than the lower part of the glass, nothing prevents the rays reaching the place where they are specially useful and desirable. The examination of the roof can be rapidly and satisfactorily carried out with this lamp, as the illumination given is far superior in that direction to any other design. Ordinary lamps must be tilted, and when in that position the light obtained is of a very inferior character.

With respect to its power to detect small quantities of gas it undoubtedly ranks superior to all others.* All ordinary forms, with the inlet above the glass, will miss, say 4 inches of gas lying immediately against the roof, except when they are tilted very much, and then there is great danger of their going out. Many lamps are now constructed to take air, if desirable, from the top, like the Gray, and then they will detect thin layers also; but even then they will not do it so *rapidly*. It is possible to put some modern lamps into gas, and take them out again without any indication being given—that is to say, if it is done hurriedly. This is quite impossible with the Gray, as the flame immediately "spires" up. In one of the pits under the writer's charge, a small accumulation of gas existed for some months in a "pot hole" against a dam in a disused road, and on many occasions several lamps were simultaneously raised into it with the object of ascertaining which would indicate first. Even with the bottom shutter holes open the Gray invariably detected the gas before any of the others. This result seems to be due to the direct way in which the ingoing current passes to the flame. Comparative tests only were employed, and the results obtained proved that this lamp showed gas to be present from 6 to 12 inches nearer the floor than any of the others. Practically this means that it detects smaller quantities. In comparison with the unbonneted Davy or Clanny, it readily shows a cap on the flame, where those lamps fail to give the slightest indication.

Numerous experiments by different individuals, have proved the safety of this type in currents of high velocity. The risk of internal explosion passing outwards is practically absent, owing to the small volume contained in the lamp, the regulation of the outlet of the products of combustion, and the conditions under which feed air is introduced. Theoretically, an internal explosion is impossible, as, owing to the admission being below the flame, any fire-damp is burnt as it arrives, and the inside of the lamp is filled entirely with the products of combustion. This, however, is not absolutely the case, as the writer has observed, on one or two occasions, a series of very small explosions take place in the lamp after it has been put in an inflammable mixture and then withdrawn.

A statement was once made to the writer, that this lamp went out so soon when introduced into gas, that it was impossible to clearly ascertain whether such gas was fire-damp or black damp—that is to say, if only small quantities were present. On the other hand, the overman who has specially been working with and examining places with this lamp for over twelve months assures the writer that not the slightest difficulty has been experienced in this respect. With black damp the flame drops and fades away, but if any gas is present a slight "spiring" of the flame is immediately noticed, and this takes place once or twice before light is lost. Of course, it is possible to abuse anything. If the lamp be pushed bodily and suddenly into gas, it certainly goes out before any definite indication is obtained; but if it be introduced slowly and steadily, and withdrawn as soon as gas is indicated, the light is not often lost.

Mueseler.—This type of lamp has deservedly been held in good repute for many years, and the report of the Mines Accidents Commission on the shielded variety was very favourable. As a detector of gas it ranks a very good second to the Gray; and it does so in a clear, delicate manner, the cap produced being very distinct.

* As the Pieler lamp cannot be used in ordinary everyday working, it is not taken into consideration.

Owing to the presence of a chimney in this lamp, when it is tilted the products of combustion pass outside the chimney and foul the inlet air, with the consequent result that the light is extinguished. This, in combination with the shield acting as a shade, make the examination of the roof a matter of difficulty. The writer's opinion, however, is, that this disadvantage of the Mueseler lamp has been rather exaggerated, as it stands a fair amount of tilting, especially if the time during which this is done be not of long duration.

Mr. Ashworth kindly forwarded two of his Mueseler's for trial. The first one, shown in Fig. 7, Plate II., is one of the safest of all lamps, as it has been tested in explosive currents of 100 feet per second without failure. It differs from the ordinary forms of this type, in having a gauze chimney instead of a metal one, and the diaphragm is conical instead of horizontal (*b*). Its safety is undoubtedly due to the double shield employed, the inner one of which is provided with a conical outlet; the exit of products of combustion is retarded, the upper part of the gauzes is kept in a bath of carbonic acid gas, and in case of any internal explosion the light is immediately extinguished, and the inlet air fouled. The arrows in the figure show the direction taken by the supply of air and the products of combustion, and it will be seen that the gauzes are protected from all violent currents. There are ten holes in the inside shield and seven in the outer one, the latter being placed near the top. A gas testing shutter (*a*) is placed above the horizontal inlet holes near the top of the glass, and when this is closed the feed air is compelled to enter through the holes in the outer shield, near the top, and pass downwards, thin layers of gas near the roof being thereby easily detected.

This lamp does not burn well in "dampy" or slow currents, and great difficulty is experienced in lighting it, and from the winding path pursued by the feed air, proper circulation does not take place until the lamp gets hot.

Mr. Ashworth also sent his A type Mueseler, which is largely employed in South Wales. The only difference between this and the preceding one, is the absence of the inner shield. There is not so much difficulty in lighting this, and it burns better in impure currents, With a view of obtaining still greater illumination where carbonic acid gas is present, Mr. Ashworth forwarded a larger chimney than the one in use; but since it arrived no opportunity has arisen to give this a trial, as the workings in the old district have been suspended.

Morgan.—Prominent attention was drawn to this lamp immediately after the report of the Accidents in Mines Commission was published. Experiments showed that it would not pass flame in explosive currents of the highest velocities.

An inner and outer shield are provided (Fig. 8, Plate II.), the latter having a series of five horizontal rows of circular holes punched through it, while the former is similarly supplied with six horizontal rows of slits. The openings in one shield are opposite the solid portion of the other. Three gauzes are used—an outer cylindrical one without a top, a middle one of the Clanny type, and an inner one, really built up of two gauzes and a chimney.

This lamp detects gas well, burns well in a good current of air, but badly in a "dampy" one, does not get hot (probably owing to its large internal volume), and stands a fair amount of tilting without the light being extinguished. After being in use several hours underground, the light gets very defective. The writer is not aware that this type has been used extensively at any colliery. It is composed of six parts, neglecting washers, and is of complicated construction. As there are many lamps perfectly safe under all ordinary conditions, it seems improbable that this form will come into large use.

Attention, however, is directed to the locking arrangement, which possesses points of novelty. Two projections, one on the oil vessel and the other on the upper

part of lamp, with vertical holes, are provided (*a* and *b*, Fig. 8, Plate II.), but the passage in the upper projection does not go completely through it. A small spring catch (*c*) is situated in the lower projection, and this will allow a cylinder, of equal diameter to the hole, to pass by, if the direction of motion be vertically upwards. The lead plug employed (*d*) consists of a cylinder with a > shaped piece cut out. To lock the lamp, the cylinder of lead is pushed in through the lower hole; it cannot go out at the top, as the covering prevents it, and it cannot be drawn back again, as the small spring catches under the >. This arrangement seems to be an improvement on the ordinary lead rivet, as time is saved.

Marsaut.—The reports of the Committee of the Ellis Lever Prize and of the Accidents in Mines Commission brought this, then new, lamp very prominently before the mining public, and results obtained in practical use increased the favourable opinion. It has, however, received a few small modifications from the form in which it was first brought over to this country, and in which it was experimented upon by the two Commissions referred to above. As originally constructed, *two* rows of inlet holes were supplied, one at the bottom of the bonnet, and the other in the horizontal flange forming the base of this part. The Accidents in Mines Commission recommended doing away with the holes at the base of the bonnet,* and in most of the lamps now constructed in this country this is carried out. After an experience of some months the writer, over a year ago, in the address previously referred to, expressed an opinion that the Marsaut lamp appeared to be the most suitable for the working miner; its construction was simple and strong, and it gave a reliable indication of gas and a good light.

Further experience has not materially altered that opinion, as, although the lamp finding most favour does not go by M. Marsaut's name, yet it is practically a lamp of this type, with an addition which increases its efficiency and lighting powers in the impure currents of return air-ways.

Deflector.—During an excursion in Lancashire the writer's attention was called to this lamp, and as complaints had been made of the difficulty in getting some of the other forms to burn brightly a few lamps of this type were obtained and placed in the hands of the miners. From the first, excellent reports were received. At the end of a shift the light given was nearly as good as it was at the commencement. After burning a short time, and getting hot, the illuminating power sensibly increases, and no difficulty is experienced in lighting the lamp when all the parts are cold.

Fig 9, Plate II., illustrates the lamp, and it will be seen that the Marsaut is followed, so far as the arrangement of gauzes, shield, oil vessel, and glass are concerned. The distinctive difference, however, consists in the guiding of the inlet air; this is admitted through a row of holes in the horizontal flange supporting the shield, and is prevented impinging on the gauze by a vertical cylinder of brass, *a*, 1¼ inches high, which acts as a guide, and directs the ingoing current vertically upwards. At a point about 1¼ inches above the horizontal flange supporting the shield, an angle ring, *b*, is introduced, the horizontal part of which completely fills up the space between the outside gauze and the inside of the shield. The other flange projects downwards close against the gauze, terminating just before reaching the vertical cylinder which proceeds from the horizontal flange forming the base of the shield. It will be noticed, that the vertical cylinder (*a*) is not placed close to the gauze, but occupies an intermediate position between that part and the shield.

The inlet air after being directed upwards meets this "deflector," and is thus thrown on to the flame. As the lamp gets hot, more air is sucked in, and passed on to support combustion. This forms the explanation why such good illumination is obtained. In all ordinary lamps a rapid circulation is obtained as soon as the parts

* Report, Vol. II., p. 84.

get hot, but no appliances are introduced to properly direct the inlet current, and as a result, the greater part passes away at once with the products of combustion, only a portion going *downwards* to supply the flame. In the "Deflector" every particle entering reaches the flame, and before doing so is heated by contact with the warm deflecting ring and gauzes.

To this heating of inlet air and proper directing of current is due the fact that this lamp will burn in an air containing such a quantity of carbonic acid gas that all ordinary forms, even unbonneted ones, are immediately extinguished.

The lamp is supplied with a solid top, *c*, and the shield is secured by a lead rivet, *d*. This is an advantage, as the locking of the bonnet can be left to the last minute, and until the miner has satisfied himself that all the parts are in their proper position. The locking arrangement for the oil vessel, is performed by a hasp (*e*) dropping over a projecting boss (*f*), through which a hole is bored for the reception of a lead rivet. The hasp, *e*, is fixed to a loose collar, *g*, surrounding the oil vessel, and as this can easily be turned round, compensation for wear on screw of oil vessel is given, and the projection (*f*) and hasp, *e*, can always be brought exactly together.

The writer had intended going into the question of illuminants for these lamps, but will simply state here that the mixture recommended by the Royal Commission on Accidents in Mines of two parts of vegetable oil to one part of best petroleum has been used for a considerable time, and has given better results than vegetable oil alone, with one exception, viz., in the case of the Hepplewhite-Gray. This lamp is so delicate that if that mixture be employed the flame has a tendency to "spire" in close, hot places, even when fire-damp is absent.

The flat form of wick is used in all lamps experimented on, with the exception of the Morgan, and to this shape is due their superior illuminating power over the old unbonneted types. A further improvement, due to Mr. A. H. Stokes, has been lately introduced. The wick tube is guttered along one side, and the wick is supplied rather wider than the tube, so that it takes a corrugated form. A larger surface of flame is obtained, and the supply of oil is better. Mr. Ashworth obtained a similar result by making the wick wider than the wick tube, and the tube broader than the wick.

A point to which little attention has been drawn is the material of which the oil vessel is constructed. In England this part is invariably made of brass, while on the Continent it is just as regularly made of iron. M. Marsaut's experiments* proved that the lighting power is influenced by the material of which the lamps are constructed, and that a brass lamp only gave 70 per cent. of the luminous intensity of the same lamp in iron. The explanation of this seems to be the superior heat conductivity of the former—the lamp bottom gets very hot, and the oil goes into a gummy state. Owing to the ease with which brass is cast, oil vessels of this material seems to be cheaper than if made from iron, such being the statement of a maker to whom the writer applied. To get over this difficulty Mr. Ashworth casts the top of his oil vessels with a bad conductor of heat (tin).

Conclusions.—Owing to the large amount of useful light given by the Hepplewhite-Gray, the way this is directed on to the roof, and the delicate indication of gas given by this lamp, it is preferred to all others for use by deputies, firemen, and timberers. It requires, however, very careful handling; and the light is easily extinguished, even when gas is absent. Men are apt to get careless, and carry it about with the lower slide holes open, and when in that state if the current impinges suddenly on the lamp the light is lost. The later form (Fig. 3, Plate I.) is by no means so sensitive to this failing as the first varieties. The distribution of light on the roof is due to the truncated cone form of glass, which is claimed to be stronger than a cylindrical one, and to automatically accommodate itself to sudden changes

* Chesterfield and Derbyshire Institute of Engineers, Vol. XII., page 232.

of temperature. The rapidity with which gas is detected is a great point in their favour. It is not too much to say, that with this lamp it is impossible to miss a small quantity, even when passing hurriedly from one place to another. This can easily be done with any of the other forms, as, unless there is an appreciable quantity of gas present, they require to be held a definite time in it before any indication is given.

For the ordinary miner, who requires something a little less delicate than the Gray, the "Deflector" lamp has yielded by far the best results. The light given in impure air is superior to that obtained from any other form, and it will continue to burn even where the unbonneted varieties will not. It gives as good an indication of gas as any other lamp experimented upon, with the exception of the Gray and Mueseler. After being in use for over a year there is not a miner at the pit who, if he had his choice, would not select this lamp in preference to any other, his reasons for this being—it burns brightly in slow and impure currents, gives a good light for a long time, and will stand a lot of knocking about.

Description of the Plates.

Plate I., Fig. 1.—Original form of Gray experimented on by Royal Commission on Accidents in Mines. The only gauze in this lamp is that shown at *b* and *c*.

„ Fig. 2.—Modification of first form of Ashworth Hepplewhite-Gray. Three tubes and high glass, outlet cone of proper height, and shield in hood properly covering inlet holes.

„ Fig. 3.—Latest design of Ashworth Hepplewhite-Gray. Glass of standard length, three tubes, cone of proper height, and hood shield, *a*, of proper diameter; an additional circle of outlet holes are provided in the top of the hood, these being covered over by a brass plate, *c*, crimped to strengthen it. After removing the oil vessel, on unscrewing the air inlet chamber, the glass and gauze fall out.

„ Fig. 4.—Section on line A B, Fig. 3, showing position of three inlet tubes.

„ Fig. 5.—Modification of the covering hood; result obtained being that the lamp is not quite so sensitive, and more applicable for ordinary use by a miner.

„ Fig. 6.—Section of ring supporting glass, a copper cone being added with a view of rendering the lamp more sensitive to gas (the ingoing current being directed on to the flame), and to make it burn better in "dampy" currents, the inlet air being heated by contact with the copper cone.

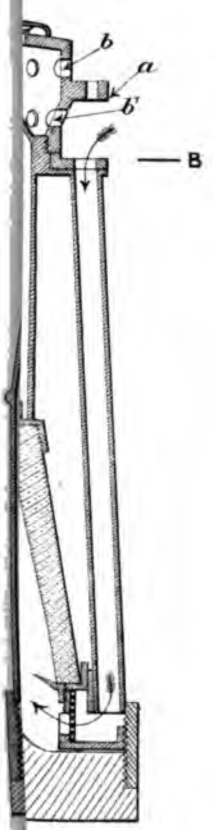
Plate II., Fig. 7.—Ashworth Mueseler, with two shields, showing gauze chimney and conical (instead of horizontal) gauze diaphragm, *b*. By closing the shutter (*a*) the supply of air is obtained from the top of lamp, and thin layers of gas near to the roof are detected. The inner shield is fitted with a conical outlet.

„ Fig. 8.—Morgan lamp, showing two shields with alternating inlet holes, the arrangement of gauzes and chimney, and the lead rivet locking.

„ Fig. 9.—"Deflector" lamp: *a*, vertical cylinder directing inlet air on to "deflector," *b*; *c*, solid top, with hole, *d*, for lead rivet locking shield; *g*, loose collar carrying hasp, and giving compensation for wear in screw thread of oil vessel.

ety Lamps".

EWHITE-GRAY.



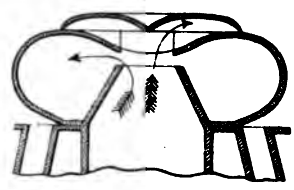


Fig. 5.

Fig. 6.

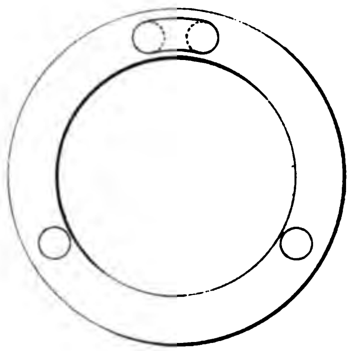


Fig. 4.

Gauze

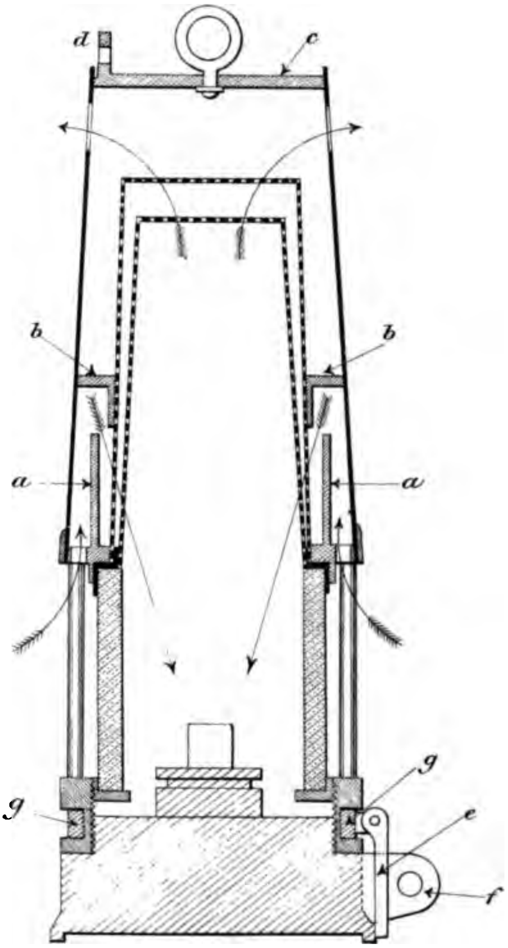
Federated Institution
Proc.

And^w Reid, Sons & Co Lithos: Newcastle

...ps."

FIG. 9.

HOWAT DEFLECTOR.



Gauze

Andw Reid, Sons & Co Lithos. Newcastle

The CHAIRMAN—We are very much obliged to Mr. Hughes for the able way in which he has given us the results of his investigations as to these lamps. I think it is a subject of which we all know more or less, and I shall be very glad if any members present would ask Mr. Hughes any questions that may occur to them in connection with the lamps which he has here alluded to. I can myself bear testimony as to the value of the Hepplewhite-Gray lamp for testing gas. It is remarkably sensitive, and I quite agree with Mr. Hughes that it is the best lamp to be put into the hands of firemen, examiners, and those who are responsible for examining the places for gas.

Mr. HUGHES—There is one thing I may not have mentioned. There was no intention to give comparisons of these lamps in so far as safety in currents of high velocity was concerned. I am not quite sure about the "Deflector" in that respect.

The CHAIRMAN—I think it may be taken for granted that in the district with which I am more directly connected, that when the Clanny lamp was in use not a single accident was traceable to it, and that was a very strong argument in its favour. It does not prevent a proper illumination of the roof, and that I consider very important. I have found that since the bonneting of lamps has taken place there have been more serious complaints than there used to be. I think the Morgan lamp, as Mr. Hughes says, certainly ought to be safe in a current. It seems to me that in putting these holes in the shield he has been trying to get a well-distributed entry of air all through. The objection with regard to this lamp going out in a stagnant current is one that I have experienced myself, and no doubt it is a source of greater inconvenience than when we had the open lamps. There is another question which is rather interesting. It is said that iron vessels are better than brass vessels on account of the greater non-conductivity of the iron than the brass. If that is really sufficiently marked to warrant the introduction of iron there would be saving at the same time.

Mr. HUGHES—In my paper there is a reference to the question of constructing lamps of iron instead of brass. On the Continent they are invariably constructed of iron, and it is proved that they have a much greater illuminating power. The explanation seems to be the superior non-conductivity of the iron compared with brass. Mr. Ashworth coats the top of the oil vessels with tin, a very bad conductor of heat.

Mr. WARDLE—Have you tried photometrically the illuminating power of the "Deflector" lamp?

Mr. HUGHES—No.

Mr WARDLE—I hear you found a defect with the glasses breaking. At our colliery, which I think was the first that introduced it into South Staffordshire, we have found the Hepplewhite-Gray is 100 per cent. better than any other lamp with regard to the breaking of glass.

Mr. HAYWARD—Do you use them?

Mr. WARDLE—Yes.

The CHAIRMAN—Do you find that they break or crack?

Mr. WARDLE—In a wet pit they will break.

The CHAIRMAN—Do you find that the men have made any sort of request for the use of those lamps in substitution for the others?

Mr. WARDLE—Well, at the lamp house, they will always have that sort of lamp out before the others.

The CHAIRMAN—The practical objection to the Hepplewhite-Gray being used in an ordinary working was the liability to go out.

Mr. HUGHES—Yes; the only objection that the men have to it is that it is too sensitive.

The CHAIRMAN—It would be interesting to know the cost of constructing the oil-vessel in iron instead of brass. It would be stronger, and you would get 45 per cent. increased light.

Mr. HUGHES—I cannot tell the cost. Iron is not so easily worked as brass.

Mr. WARDLE—Rough tin would almost answer the same purpose if it was lined inside the brass.

Mr. GLENNIE referred to the question of cleaning, which was an important matter when there were a lot of lamps.

Mr. ADAMS—I should like to ask Mr. Hughes if he thinks, after the experiments he has made, there is not room for considerable improvement?

Mr. HUGHES—Well, I should not like to go that far.

On the motion of the CHAIRMAN, seconded by Mr. GLENNIE, a vote of thanks was accorded Mr. Hughes for the paper which he had given.

Mr. HUGHES said that he was only too pleased at any time to give them any results that he might obtain in working. He wrote that paper simply with the object of promoting a discussion.

THE ISSUE OF THE TRANSACTIONS.

The CHAIRMAN asked when it was likely that this paper would be printed and in the hands of the members?

The SECRETARY—In the ordinary way it will be sent in at once to the Federated Institution.

The CHAIRMAN—I should think it will not be later than the third week in September. I think it might be well to leave the question for further discussion. When other members have read the paper they may have something to say.

The CHAIRMAN reported the deaths of Mr. Richard Latham, a member of the Institute for twenty-one years, and for a considerable time Treasurer, and Mr. John E. Wright. The Secretary was instructed to convey a vote of condolence to the families of the deceased members.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

MEETING,

HELD AT SHEFFIELD ON JANUARY 22ND, 1890.

MR. GEORGE LEWIS, PRESIDENT, IN THE CHAIR.

The following were declared to have been duly elected :—

MEMBERS—

Mr. Thomas W. S. Bramley, Mechanical Engineer, Treeton, near Rotherham.
Mr. Robert Calderwood, Colliery Manager, Trowell Moor Colliery, Stapleford, Notts.
Mr. George Chalmers, Engineer, c/o St. John del Rey Mining Co., 28, Tower Chambers, Finsbury Pavement, London, E.C.
Mr. William Howe, Mechanical Engineer, Clay Cross, Chesterfield.
Mr. Charles Snow, Colliery Manager, Glapwell Colliery, near Chesterfield.

ASSOCIATE MEMBER—

Mr. Charles Soar, Enginewright, Granville Colliery, Swadlincote, near Burton-on-Trent.

N.B.—This being the date of the meeting of the Federated Institution in Sheffield, the separate meeting of the Chesterfield Institution was held *pro formâ* for the admission of new members only as above.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE STEPHENSON MEMORIAL HALL, CHESTERFIELD,
SATURDAY, 12TH JULY, 1890.

MR. GEORGE LEWIS, PRESIDENT, IN THE CHAIR.

The CHAIRMAN (Mr. George Lewis, the retiring President) said the first business of the day was the election of officers for the year 1890-91.

Messrs. G. Hewitt and W. D. Holford undertook the office of Scrutineers of the ballot papers.

The CHAIRMAN then moved the adoption of the General Report of the Council, including the Finance Report of the year. Each member had received a copy, and he therefore would suggest that the reports be taken as read. He would like to make one or two very short remarks upon them, and then they would be pleased to hear what any other gentleman had to say further. It would be noticed, in the first place, that the Institution was not in the flourishing condition they could wish; and he was very much afraid this was the rule with several institutions of the same character as their own. The number of members had been pretty well maintained, although there was a slight decrease within the last three or four years. The work of the Federated Institution of Mining Engineers was pretty well understood, and had recently been so fully explained that he did not think it necessary further to allude to the question. One other matter arose, and it was a very important one to the Institution: the deficiency of papers, of which of late there had been a very great dearth. He had hoped, during his year of office, that several more papers would have been read before the Institution. Unfortunately it had not been so, but he hoped that defect would be remedied in the near future. There might possibly be several causes that had brought about this state of affairs; but now the papers were more extensively published, and their usefulness extended in a variety of ways, he hoped that those gentlemen—and there were many among them—who were able to write very competent and exhaustive papers would do so during the present year. They would notice that the Federated Institution of Mining Engineers was to meet at Nottingham in September; and the Council hoped that if possible every one of their members would be present at the meetings, either on the day devoted to reading papers or on the next, when it was intended to have a number of short excursions to the various collieries and other works of the district. They could not have forgotten the kindly manner in which they were taken in hand by the Mayor of Sheffield and the Master Cutler at their meeting in Sheffield some little time ago, and he hoped that something similar might be arranged in Nottingham. He took upon himself the other day the duty of mentioning the matter to the Mayor of Nottingham (Mr. Alderman Goldschmidt), and although without promising that he would in any way assist them, the Mayor said that the influence of the town authorities would be exerted towards making the meeting both instructive and pleasant. He moved the adoption of the Report of the Council and their Finance Report for the past year.

Mr. W. E. WELLS (Eckington Collieries) seconded, and the motion was agreed to unanimously.

REPORT OF THE COUNCIL.

The following is the usual comparative summary of numbers and finance in the past three years, viz.:—

	1887-8.	1888-9.	1889-90.
Honorary Members	14	15	15
Life Members...	8	8	8
Members	193	193	187
Subscribing Members	6	6	7
Associate Members	25	25	26
Students	10	11	10
	256	258	253

	£	s.	d.	£	s.	d.	£	s.	d.
Cash Receipts	365	10	11	367	11	3	342	4	0
Cash Payments	332	18	2	373	12	5	330	1	3
Bank Balance	40	7	3	34	6	1	46	8	10
Invested Fund	430	0	0	430	0	0	430	0	0
	£470	7	3	464	6	1	476	8	10

Arrears considered recoverable at end of	1887-8.	1888-9.	1889-90.
	£101 0 6	91 3 6	89 3 6

Twelve new Members (including 2 Students transferred), 1 Subscribing Member (transferred by request from Members' list), 2 Associate Members, and 1 Student have been elected during the year—total 16 (as against 25 last year).

The total retirements from all causes are 21 (as against 25 last year), viz.:—18 Members (1 of whom is now a Subscribing Member), 1 Associate Member, and 2 Students (now Members).

There has been a net decrease of 6 Members and 1 Student, and a net increase of 1 Subscribing Member and 1 Associate Member.

One death during the year has been recorded, and will be further referred to in a Memoir.*

The total number on the roll of the Institution as at 26th March last, was 253.

The income of the past year was £25 7s. 3d. less than that of the previous year, chiefly owing to the decreased number of new members. The arrear list is still heavy, and prompt payment is again urged.

The expenditure has been £43 11s. 2d. less than that of the previous year, and £12 2s. 9d. less than the year's income.

* See page 286.

This favourable statement is, however, qualified by the consideration that although £84 actually paid to the Federated Institution on account as a part contribution for a half year is included, the full year's payment will almost certainly be somewhat more than double that amount: which larger sum added to the cost of the printing that must necessarily be done for this Institution, as an independent member of the Federation, will greatly exceed the ordinary annual outlay.

The greater quantity of printed matter and technical information obtained through the joint publication of the Transactions of the four Federated Institutes, and of other Institutes who may be expected eventually to join, cannot, as the Council have before pointed out, be reasonably expected to be supplied for the same annual contribution per member as has sufficed for the work of this Institution singly. In thus repeating the view expressed in their last year's report, the Council desire only to keep it before the minds of members, without making further call upon them at present.

As to the work of the Federation:—Two issues of the joint Proceedings and Transactions have been distributed to members of all classes, and another part is in the printers' hands. The First General Meeting of the Federated Institution of Mining Engineers was held in Sheffield on the 22nd and 23rd January last, and was numerously attended. Three important papers were read, and a dinner and conversazione, the latter given by the Mayor and Master Cutler, occupied the first day. The second day was devoted to excursions to collieries. Another General Meeting took place in London, on 30th April. The next meeting of the Federated Institution is to be held in Edinburgh, on 24th and 25th July instant, where the Exhibition will be a chief attraction. It is further projected that a meeting shall be held at Nottingham in September next, and for this occasion the Council invite the active and cordial co-operation of the members of this Institution.

Papers of interest, particularly such as relate to the Midland Coal Mines Inspection district, are especially desirable, and owners and managers of mines and works are invited to offer facilities for inspection by the visitors. It is to be hoped that with the stimulus of such an assemblage of mining engineers as may be expected amongst us in September, will re-commence a period of activity in the contribution of papers by Members and Students of this Institution. In this respect there has been a conspicuous falling off by comparison with preceding years, and partly to this defect may be ascribed the paucity of new candidates for admission to membership.

The Council feel that they cannot too strongly impress upon all the members, individually and collectively, the necessity for bestirring themselves to recover the lost ground as to members and as to papers. The further issue of the joint publication, in which important and suggestive papers on details of practical working have already appeared, should have the effect of rapidly and considerably augmenting the membership, if judiciously brought by existing members under the notice of their mining acquaintance who have not yet joined; and the more extended publication in permanent form of authors' papers, should have the effect of inducing each member to do his best to record his knowledge and bring out that of others upon questions in which he is interested, for his own credit and advantage, and that of the district and profession. One result of the new rule, "The President shall be elected annually, and shall not be eligible for re-election for a year after," has been that the President of the year (Mr. George Lewis) delivered an inaugural address. From a mining engineer of his large practice and long experiènce this has formed a valuable precedent that the Council consider and desire should be annually followed. It was besides a welcome addition to the few papers on special subjects which the year has produced.

The complete list of papers is as follows :—

*Presidential Address. By Mr. George Lewis.

*"Notes on the Geology of the Manchester Canal." By Mr. C. E. De Rance.

Programme and Account of the Manchester Ship Canal Excursion. Compiled by the Secretary.

*"A recent Boring at Chesterfield with the Diamond Drill." By Mr. G. Elmsley Coke.

"Soar's Patent Coal-Lowering Apparatus." By Mr. Charles Soar.

The Papers marked * have been printed in the Transactions and Proceedings of the Federated Institution of Mining Engineers, where the following contributions of the other Federated Institutes, likewise appear. As all the papers published by the Federated Institution are open to discussion at the meetings of each institute, as well as at the Federated Institution meetings, it is proper to record the list in this report of the work of the past year. It is further advisable to do so, that it may be seen what the other institutes have done, and that the general advantage from the joint publication may be duly apparent.

North of England Institute.—"Winding, Banking Out, and Screening Plant at East Hetton Colliery." By Mr. S. Tate.

"Obituary Notice of the late M. Théophile Guibal." By Mr. W. Cochrane.

"Improved Coal Screening and Cleaning." By Messrs. T. E. Forster and H. Ayton.

Midland Institute.—"On an Outburst of Gas in the Haigh Moor Seam at Whitwood Collieries." By Mr. W. G. Jackson.

"On an Outburst of Gas at Houghton Main Colliery." By Mr. J. Jarratt.

"On Overwinding and its Prevention." By Mr. A. Bertram.

"On a Patent Apparatus, Indicator, and Valves for the Automatic Prevention of Overwinding at Mines." By Mr. C. H. Cobbold.

"Notes on the 'Medium Fan' (Patent)." By Mr. Arnold Lupton.

South Staffordshire Institute.—"Notes on Mining in North Mexico." By Mr. W. H. Glennie.

Federated Institution.—Presidential Address. By Mr. John Marley.

Federated Institution (Midland Institute)—"The Geology of the Southern Portion of the Yorkshire Coal-field." By Mr. R. Russell.

Federated Institution (Midland Institute)—"Coal-getting by Machinery." By Mr. G. B. Walker.

The Excursion, of 15th August last, to the Manchester Ship Canal Works, in progress, was made at the suggestion of the President, and was highly interesting and successful, not the least agreeable feature of the day being the dinner given on the occasion to the large party by the President of this Institution (Mr. G. Lewis), who has made his year of office memorable, not only in the particulars above-mentioned, but by constant assiduous attention at every General Meeting and nearly every Council Meeting.

The Annual Meeting this year has been fixed to be held in Chesterfield on 12th July proximo, the members dining together afterwards, and Mr. Jackson, the President-elect, presiding.

This meeting and the Federated Institution meetings at Edinburgh and Nottingham together, it is thought, render another excursion superfluous. A full equivalent is intended to be provided in connection with the Nottingham meeting.

APPENDIX.

Donations to the Library and Museum.

British Association for the Advancement of Science. Report of Meeting at Newcastle-on-Tyne, 1889. From the Association.

Colliery Explosion at Mossfields, Staffordshire. Two Reports. From Mr. W. N. Atkinson, H.M. Inspector of Mines.

Colliery Management; and Haydock Mining Lecture. Two Pamphlets. From the Author. Mr. C. M. Percy.

Mineral Statistics of the United Kingdom, 1888. From Mr. A. H. Stokes, H.M. Inspector of Mines.

Mines. H.M. Inspector's Report for the Midland District, 1888. From Mr. A. H. Stokes.

Mines. List of Mines worked in the Year 1888. From Mr. A. H. Stokes.

Mines. List of Plans of Abandoned Mines to 30th June, 1889. From Mr. A. H. Stokes.

National Boiler Insurance Company. Chief Engineer's Report, 1888. From the Company.

Potts' Mining Register and Directory, 1889. From Mr. W. J. Potts.

Spon's Engineers' and Contractors' Diary and Reference Book for 1890. From Messrs. E. and F. N. Spon.

Chesterfield and North Derbyshire Almanac for 1890. By Mr. T. P. Wood. From the Author.

Year Book of Scientific Societies, 1890. Purchased.

Smithsonian Institution, U.S.A. Annual Report to June 30th, 1886. Part I. From the Institution.

California State Mining Bureau. Ninth Annual Report, 1889. From the Bureau.

The New Dressing Works of the St. Joseph Lead Co., at Bonne Terre, Missouri. Pamphlet.

The English *versus* the Continental System of Jigging. Is close sizing advantageous? Pamphlet. From Prof. A. Munroe.

"The Colliery Manager." (Monthly.) From the Editor.

"Machinery Market." (Monthly.) From the Editor.

"The Colliery Engineer," Pennsylvania. (Monthly.) From the Editor.

Exchanges.

Civil Engineers, Minutes of the Institution of. From the Institution.

Cleveland Institution of Engineers, Proceedings of the. From the Institution.

Liverpool Engineering Society, Proceedings of the. From the Society.

Manchester Geological Society, Transactions of the. From the Society.

Mechanical Engineers, Proceedings of the Institution of. From the Institution.

North of England Institute of Mining and Mechanical Engineers, Transactions of the. From the Institute.

Scotland, Mining Institute of, Transactions of the. From the Institute.

South Wales Institute of Engineers, Proceedings of the. From the Institute.

South Staffordshire and East Worcestershire Institute of Mining Engineers, Transactions of the. From the Institute.

United States Geological Survey. Seventh Annual Report. From the Survey Department.

Pennsylvania, U.S.A., Second Geological Survey of. From the Survey Department.

ABSTRACT OF ACCOUNTS, YEAR ENDING MARCH 26TH, 1890.

	Income.	£	s.	d.	£	s.	d.
147	Members	231	10	6			
	Two formerly Students paid Entrance	1	1	0			
5	Subscribing Members	5	5	0			
1	Do. paid balance	0	10	6			
25	Associate Members and Students ...	25	0	0			
	One paid up from date of Election ...	1	0	0			
5	New Members and Entrances	13	2	6			
2	New Associate Members and Students	2	0	0			
185					279	9	6
	Two Members paid in advance ...	3	3	0			
	Three New Members paid in advance, and Entrances	7	17	6			
	One New Associate Member in advance	1	0	0			
					12	0	6
	Arrear Subscriptions received 1887-8...	6	6	0			
	Do. do. 1888-9...	24	1	0	30	7	0
					321	17	0
	Transactions and Excerpts sold ...				2	10	0
	Midland Railway Debenture Interest				15	12	0
	Bank Interest				2	5	0
	Total Receipts...				342	4	0
	Unpaid Arrears, per Subscription a/c...	78	14	6			
	Do. 1888-9 Account ... 39 10 0						
	Do. 1887-8 do. ... 15 12 0						
	Do. 1886-7 do. ... 5 14 6	60	16	6			
		139	11	0			
	Irrecoverable	50	7	6			
	Net arrears to collect				89	3	6
	Balance from last year				34	6	1
					£465	13	7

Expenditure.	£	s.	d.	£	s.	d.
Bemrose & Sons, Printing Transactions—						
Vol. XVII., Part IV.	7	11	6			
Vol. XVII., Part V.	12	6	6			
Vol. XVII., Part VI.	4	2	0			
Excerpts	3	8	10			
				27	8	10
Bemrose & Sons, Printing and Stationery	10	19	2			
Sundry Printing and Stationery	1	7	6			
				12	6	8
Federated Institution of Mining Engineers: Two Quarters' contribution for Printing Proceedings, etc.				84	0	0
Auditors				3	3	0
Reporting Proceedings				11	11	0
Stephenson's Memorial Hall--Occupation				14	1	5
Fire Insurance				0	12	6
Postages, Parcels, and Telegrams				15	13	4
Travelling and Incidental Expenses ...				12	10	8
Requisites and Services				2	6	9
Manchester Excursion Meeting				5	19	5
Secretary's Salary, Assistance, and use of Office				140	0	0
Bankers' Charges				0	7	8
Total Expenditure ...				330	1	3
Balance in Crompton & Evans' Union Bank, Limited, Chesterfield, June, 1890	88	6	4			
Less on Account of forward year	41	17	6			
				46	8	10
Arrear Subscriptions...				89	3	6
				£465	13	7

June 27th, 1890.—Examined and found correct.

THOMAS WILKINSON, }
JOHN HALL, } AUDITORS.

Mem.—Amount paid for £400 M.R. Co.'s 4 per Cent. Debentures £430, and Certificates deposited in Crompton & Evans' Bank.

THE TREASURER IN ACCOUNT WITH SUBSCRIPTIONS, 1889-90.

Dr.

No.		£ s. d.	£ s. d.
193	Members as per List, 1889-90	303 19 6	
	Less three paid in advance last year ...	4 14 6	
			299 5 0
	Two formerly Students paid Entrance	1 1 0	
	Two paid in advance, 1890-1	3 3 0	
	Three New Members do. and Entrance	7 17 6	
			12 1 6
6	Subscribing Members	6 6 0	
	Less one paid part previously	0 10 6	
			5 15 6
36	Associate Members and Students ...	36 0 0	
	One paid arrear not in List	1 0 0	
	One New Associate paid in advance, 1890-1	1 0 0	
			38 0 0
5	New Members and Entrances	13 2 6	
2	New Associate Member and New Student	2 0 0	
7			15 2 6
242			370 4 6
	Arrears per last Balance Sheet ...	91 3 6	
	Deduct Irrecoverable Arrears not included in 1890-1 List...	50 7 6	
			40 16 0
			£411 0 6

June 27th, 1890.—Examined and found correct.

THOMAS WILKINSON,
JOHN HALL, } AUDITORS.

Cr.

No.		Unpaid. £ s. d.	Paid. £ s. d.
147	Members		231 10 6
3	Paid last year in advance		
43	Unpaid	67 14 6	
193			
	Two formerly Students paid Entrance		1 1 0
	Two paid in advance 1890-1		3 3 0
	Three New Members do. and Entrance		7 17 6
5	Subscribing Members paid		5 5 0
1	Do. paid balance		0 10 6
6			
25	Associate Members and Students ...		25 0 0
	One paid Arrear not in List		1 0 0
11	Unpaid	11 0 0	
36			
	One New Associate paid in advance...		1 0 0
5	New Members and Entrances ...		13 2 6
2	New Associate Member and New Student		2 0 0
7		78 14 6	291 10 0
	Arrears as per last Balance Sheet ...	60 16 6	30 7 0
		£139 11 0	321 17 0
	Irrecoverable	50 7 6	
			89 3 6
			£411 0 6

The SECRETARY (Mr. W. F. Howard) announced that the following gentlemen had been found duly elected by ballot:—

MEMBER—

Mr. Jeremiah Rhodes, Colliery Manager, Shirland Colliery, near Alfreton.

STUDENTS—

Mr. James Tardif Browne, Blackwell, near Alfreton.
Mr. Thomas George Hughes, Blackwell, near Alfreton.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The CHAIRMAN said he had now to move, on behalf of the Council, "That the resolution passed at the annual meeting in June, 1889, in relation to the Federated Institution of Mining Engineers, be extended to include the current year and volume of the Federated Institution or until further consideration at a special or the next annual meeting." There arose a little difficulty about this, owing to the year of the Federated Institution not expiring until September or March of next year, and as their joining was intended to include the whole of the year of the Federated Institution, he must ask them to be good enough to extend the time, and pass the resolution as drawn by the Council for the purpose.

Mr. J. P. JACKSON (Clay Cross) seconded. He did not think they had had sufficient experience to say whether they were satisfied or not with what had been done, and it would be better to remain for another twelve months before making any alteration.

Mr. M. H. MILLS (Chesterfield) said he felt sure that the Federated Institution could not be carried on at the small subscription now being paid, and the members of this Institution must look forward to paying a slightly increased subscription. He thought it was better to mention the matter now, so that it would not come upon them suddenly at the end of next year. The work of the Federated Institution was a great deal more useful than that of any small institution; their libraries were being enriched, and he did not think anyone would object to pay a slightly increased subscription at the end of next year.

Mr. J. A. LONGDEN (Teversal) did not wish to appear in opposition to Mr. Mills, but he thought it would be a great mistake for it to go out from that Institution that they were intending to raise the subscription. He had made some remarks in the Council on this subject, and did not wish to repeat them here; but he thought there might be some economy in management. He always supposed an institute which was working in connection with others in publishing, etc., could be conducted on more economical lines than if it stood alone. One of the Federated Institutes was receiving from its members £1 1s. subscription and an additional 15s. per annum, which absolutely went to the Federated Institution. That made a total yearly contribution of £1 16s. So that the present contribution of the Chesterfield Institution, £1 11s. 6d., was only 4s. 6d. per annum less than that of the institute in question. He thought it highly important that nothing should go forth to their members, or those who might be members, that there would be a great increase in the subscription in order to maintain connection with the Federated Institution. His own impression was that they ought to be able to manage with their present subscription: if people would only pay at the proper time, and thus prevent the large annual

loss from irrecoverables. Looking at the report of the Council they would see that the amount of arrears considered recoverable at the end of 1887-8 was £101; for 1888-9 they were £91; and for last year, £89. Moreover, in each of those years a sum of about £50 had been previously written off as absolutely irrecoverable. There was, as the account showed, a small reserve fund invested. He did not see why, if it was necessary, they should not make a small call on this fund, and thus avoid raising the subscription. What they wanted was more members and more papers, and he therefore did not want anything to be said outside which would prevent the growth and usefulness of the Institution.

Mr. A. H. STOKES (H.M. Chief Inspector of Mines, Derby) said there was one remark he would like to make in support of Mr. Longden's statement that they wanted more members and more papers. They certainly wanted more papers, but they also wanted less delay in the printing of papers after they had been read. He did not know whether it rested with their Secretary or with the Secretary of the Federated Institution, but certainly they did not get the papers issued as quickly as he thought they should be. Was it because the Federated Institution was waiting for other institutes to send in their papers? If that was so, could it not be arranged that the quarterly meetings should all be held upon the same day, and then all the papers placed in the Secretary's hands in a few days afterwards? But if some institutes held their meetings half-way between theirs, and the Secretary waited for those papers, of course delay would result. He thought if matters could be so arranged to expedite the publication of the papers it would be a great advantage to members.

The CHAIRMAN said he must say that he was not quite satisfied with the way in which the work had hitherto been done by the Federated Institution; but he thought, looking at the fact that everything was new, it must naturally take a little time to work round satisfactorily, and he hoped the points that had been raised would have attention; but he thought if they would pass the resolution, the other matters, which were simply matters of detail, could be easily remedied at the next Council meeting of the Federated Institution.

The resolution was carried *nem. con.*

ELECTION OF OFFICERS.

The Scrutineers (Messrs. G. Hewitt and W. D. Holford) presented their statement of members elected on the Council for the ensuing year.

The CHAIRMAN read the list, and expressed the thanks of the meeting to the Scrutineers.

The complete Council list is as follows:—

PRESIDENT.

John P. Jackson, Esq., J.P., M. Inst. C.E., Clay Cross, Chesterfield.

VICE-PRESIDENTS.

G. E. Coke, Esq., Corporation Street, Chesterfield.

G. Hewitt, Esq., Unstone, Sheffield.

W. D. Holford, Esq., Whittington, Chesterfield.

H. Lewis, Esq., Annesley Colliery, Nottingham.

J. A. Longden, Esq., Teversal, Mansfield.

M. H. Mills, Esq., Corporation Street, Chesterfield.

COUNCILLORS.

S. Alsop, Esq., Pinxton Collieries, Alfreton.

G. S. Bragge, Esq.. Granville Colliery, Burton-on-Trent.

P. M. Chester, Esq., Oakwell Colliery, Ilkeston.

M. Deacon, Esq., Blackwell Collieries, Alfreton.

E. Eastwood, Esq., Railway Wagon Works, Chesterfield.

H. Fisher, Esq., Clifton Colliery, Nottingham.

G. Howe, Esq., Clay Cross, Chesterfield.

C. H. Oakes, Esq., Holly Hurst, Alfreton.

C. H. Seely, Esq., Sherwood Lodge, Arnold, Notts.

J. B. Smith, Esq., Newstead Colliery, Nottingham.

H. Walters, Esq., Birley Collieries. Sheffield.

W. E. Wells, Esq., Eckington Collieries, Chesterfield.

Ex-Officio { Lord Edward Cavendish, M.P., Chatsworth, Chesterfield. George Lewis, Esq., M. Inst. C.E., F.G.S., Albert Street, Derby. } Past-Presidents.

TREASURER.

E. Eastwood, Esq., Railway Wagon Works, Chesterfield.

SECRETARY.

W. F. Howard, Esq., 13, Cavendish Street, Chesterfield.

The CHAIRMAN said the only remaining duty for him to perform was to vacate the chair in favour of their President for the year, Mr. Jackson. He was sure he would be heartily welcomed by each and every member of the Institution, for no better man to his knowledge could have been chosen, and he was one from whom they might look to receive assistance in every possible way. He hoped that during Mr. Jackson's year of office there would not be the dearth of papers which latterly had unfortunately prevailed. He would suggest a little more whipping up, and if by this means a better state of things could be brought about, they would fully appreciate his efforts. As regarded himself, he could only say it had been a great pleasure and honour to act as their President for the past year. He was afraid in some matters they must take the will for the deed; but where he had unfortunately failed, it had been not from any want of exertion of his own, but simply from inability. The Institution had a great future before it, and the important mining district of the Midlands deserved to be fully and well represented by them in the Federated Institution and combined districts. There were extensive mining operations being carried on, and he thought without any egotism, he could safely say there were no more skilfully planned collieries or plant to be seen in any other district than could be found in their own. Consequently, there must be ability. He hoped they would in the future rally round their Institution and support it, not only by writing papers, but also by showing their interest in it by attending the meetings. This applied particularly to their proposed Nottingham meeting where their new President would require their support. He felt personally that a duty devolved upon each member, and he was sure they would be equal to the occasion, with the result that it would be a successful gathering. Without further addressing them he begged to vacate the chair in favour of the President for the year, Mr. Jackson.

Mr. JACKSON then took the chair, and delivered his address, as follows:—

PRESIDENT'S ADDRESS.

BY MR. J. P. JACKSON.

I heartily recognise the honour you have conferred upon me by electing me President for the ensuing year, but at the same time I cannot refrain from remarking that it would be more convenient if the Council would intimate their intention to the person they desire to recommend for the office before nominating him for election.

Had I been consulted, I should have declined the compliment from a feeling of inadequacy to fill such an important position, in consequence of my not being able to devote the time and attention that such a responsibility demands.

Our Secretary pointed out to me the inconvenience that would arise through having to appoint another President after the annual meeting, so I have accepted the office, and now ask for your greatest forbearance if I inefficiently perform the duties allotted to me.

I have been a member of this Institution from its commencement, and in trying to compile a few remarks have referred to our Proceedings, and endeavoured to collect from them some idea of the advantages that have been offered to us.

Our last President, in the concluding remarks of his address, referred to the proposed Federation of Mining Institutions. Since then such a scheme has become an accomplished fact, and already we have a volume of papers and discussions that have taken place in different parts of the country. Federation has practically been in operation from the early days of engineering; indeed, without the co-operation of the different branches no undertaking could be accomplished.

In the construction of a railway, for instance, we have the civil engineer, the chief designer, who again has to call in to his aid the mining engineer and the mechanical engineer, and, latterly, the electrical engineer; each have their own distinctive work, but all are necessary to the completion of the undertaking.

Every year this is more fully recognised, as is proved by the fact that the Institution of Civil Engineers, the parent society, generously offers its home in London for the annual meetings of engineering institutions.

The most important triumphs of engineering skill lately have been the successful completion of the Forth Bridge and the Eiffel Tower at the Paris Exhibition—both wonderful examples of steel and iron work. Following in their track is the Manchester Ship Canal, which some of us had an opportunity of inspecting last year.

These are all schemes that some years ago would have been considered too gigantic to have been undertaken.

As far back as 1852, the late Nicholas Wood, President of the North of England Institute of Mining and Mechanical Engineers, said, "The object of this Institution is two-fold—first, by the union and concentration of professional experience to endeavour to devise measures to diminish mining accidents; and, secondly, to establish some kind of literary association to obtain knowledge of coal mining and other matters which are not contemplated in the ordinary literary associations which have hitherto been established." Federation was evidently in his mind then, and he referred again to those remarks when he presided at the meeting of that institution held at Birmingham in 1861, at which I had the privilege of being present. The desire expressed then has been well fulfilled.

In the 17 or 18 volumes of Transactions which this Institution has published there is scarcely a question the mining engineer is interested in that has not been touched upon, and in these volumes we have not only a complete record of this literary association, but they contain a large amount of very valuable scientific information.

The honour you have conferred upon me created in me a desire to look into these volumes, and to glance over the papers written years ago, and to recall to memory the men who contributed them.

The inaugural address of our first President, who, although not a practical engineer, grasped with skill the objects for which our Institution was formed, after reviewing most ably the mining questions of the day, urged upon the members the desirability of imparting useful information to each other. This undoubtedly has been done, with the result that great improvements have been made in mining operations, notably in sinking, ventilation, method of working, banking and screening coal, construction of winding and pumping engines, safety-lamps and use of explosives, and a variety of other work connected with mining.

Much has been written from time to time on these subjects, but they afford such ample scope for further consideration and discussion that I would suggest that some of the new papers for the ensuing year should embrace one or other of the foregoing branches.

It is necessary for a mining engineer to have a knowledge of the geology of his county, and this the Rev. Mr. Mello helped us to, at an early stage of our existence, in his paper entitled "A General Sketch of the Geology of Derbyshire."

Following this subject, we have had able papers on lead mining in Derbyshire, by Mr. Stokes, in which he treated very carefully the geological features of that industry.

Boring is a subject that has been dealt with by the same author; and lately this useful mining operation has brought to light coal in the South of England, but whether so accurately as to warrant the sinking of shafts remains to be seen. Even if collieries were opened in the south the demand for coal increases so rapidly that a market would, in my opinion, be found for it without any detriment to present colliery districts. We have had some interesting papers upon sinking shafts and how to deal with different strata as passed through. Shafts in the future will probably be deeper than any at present in use as the shallower beds of coal become exhausted. There was a time when sinking was frequently commenced before the necessary plant had been erected, but no engineer would now attempt such work before he had provided for all exigencies.

Winning and working in different districts and countries have been demonstrated to us, and the experience of others has doubtless helped us to get coal in a more economical way and produce a large proportion of the seam worked.

We have had a very instructive essay upon the uses of coal from a chemical point of view, also written by Mr. Mello, which enlightens us as to the importance of a mineral which earlier in the history of the coal trade was estimated so lightly.

The ventilation of mines, and the mechanical means used in effecting the same, have been touched upon, and perhaps raised more discussion than any other subject. In the early days of this Institution there was a war of fans, and furious battles raged without any decisive victory. The truce that was then made seems likely to end, as recently two fans have been introduced to eclipse those of earlier date.

In due course the merits of these will be fully discussed, and the discussion will be exceedingly interesting. Any machine that is designed for this purpose only adds to the means for better securing comfort and safety to men employed underground, and will be a source of satisfaction and profit, I hope, to the inventors.

More than one paper has been written upon the different methods of raising water out of mines. Cornish engines appear to have been superseded by more handy, if not more economical machines, which are forcing water to a height of 300 or 400 yards.

This is a question that should be of interest to the mining engineer, and further papers on the systems in use would be valuable.

Great improvements have been made in underground haulage, and it would be invidious to advocate one system in preference to another. Amongst us we have gentlemen practically acquainted with all of them, but the descriptions that have been given to us from time to time will help others in coming to a conclusion. With regard to the power used I hope there are very few instances, if any, where steam is generated underground. Such a practice has more than once been the cause of disastrous results. Where steam is used it should be conveyed from the surface.

Much attention has been paid to the efficiency and improvement of safety-lamps, and we have a valuable report upon experiments made by members of this Institution that will remain as a work of reference for future generations, or so long as oil is used as an illuminant. The day will probably come when electric lamps will take the place of the present ones, but up to now nothing has been designed to supersede the latter. The distribution of the light and the weight of those electric lamps that have been introduced requires much improvement.

We have had many safety-lamps brought to our notice, with the result that we have now in use several capable of dealing with whatever gas may be found in the pits of our district.

The use of explosives has had considerable attention, but until something is found that will explode or be fired without emitting flame, perfect immunity from this source of danger cannot be secured. A greater use of coal-cutting machines worked under more economical conditions than exist at present, coupled with wedging, may in the future take the place of blasting.

Screening and cleaning coal on belting, washing and coking slack, have all been described, and the process used in the latter has been the means of effecting economy in the consumption of fuel at collieries where coke is manufactured; for steam is now generated by the heat from the ovens, which even yet in many cases is allowed to be wasted.

The manufacture of iron maintains a prominent position in the industry of our district, and furnaces have of late years been erected to make it more economically and in larger quantities than was done in 1871.

The working of iron ore has almost ceased in Derbyshire, as that found in Northamptonshire and Leicestershire can be delivered at our furnaces at considerably less cost. The effect has been an interchange of commodities, as the furnaces erected on these ironstone fields consume a large portion of the coal and coke we are able to produce.

There were some forty-two furnaces in blast in this district last year, consuming about 12,000 tons of coal or its equivalent in coke weekly, a proof in itself of the important part that iron-making should take in our Proceedings.

Through the courtesy of Mr. Stokes I have been able to read an advance copy of his report for 1889, and I am glad to have this opportunity of saying, that in his district as compared with others, the increased output of coal bears an inverse proportion to the loss of life.

Perhaps the most satisfactory part of the report is that for the last two years no fatal accident has occurred from explosion of gas. It is to be hoped that such a condition will continue, but from the treacherous nature of the roof in so large a part of his district we can scarcely expect to be entirely free from calamities.

In 1868 the loss of life was one for every 128,321 tons raised, last year it was one to 310,093, the best result that has been obtained in any district in the United Kingdom, and one which I consider mainly due to the improved conditions under which we now work.

Mr. Stokes also points out as an interesting fact that the bulk of the coal is worked at a depth of between 100 and 900 feet, although in one or two instances in Derbyshire and Nottinghamshire it is got in pits 1,700 feet deep. This proves

that we are a long way off the limit of 4,000 feet, the depth at which the Royal Commission of 1861-71 considered coal could be worked. We may, therefore, rely upon having mining operations to conduct for a very long period.

Other matters of interest are referred to by Mr. Stokes, such as workmen's insurance and ambulance work, both of which are deserving of support by all connected with mining.

I would impress upon all students the necessity of taking advantage of the scientific education which is now so liberally offered at mining colleges and various centres where science classes are held.

Sir J. Kitson in his address to the Iron and Steel Institute quoted the following remarks of a German professor:—"Whilst you in England have been busy for the last half-century in perfecting your machines, we in Germany have been busy in perfecting our men."

I think we may take a hint from this, and would do well to secure technical and scientific education for those who, in the future, will have increased competition to face.

I would just refer to two questions of interest to us all—the Royal Commission now sitting to consider mining royalties, and the eight hours' movement.

With regard to the former and how far it will affect the economic condition of trade, I gather that the Blue-book of evidence when published will be exceedingly instructive to mining engineers, as it will detail the various methods of leasing practised in this country, and may lead to a general revision of terms.

Referring to the eight hours' movement, should it ever be adopted, the problem will then be how to raise an increased quantity of coal in less time than now, otherwise the total output of the country must be diminished. Engineers have hitherto been able to grapple with any difficulty that has presented itself, and if this arises it will doubtless be overcome.

In reviewing the history of mining, nothing is more remarkable than the vast strides that have been made in the means used in producing coal, and it will particularly strike those who are old enough to remember the crude methods in existence in former days.

Much has been achieved, but much remains to be accomplished in mining operations, and in no direction more forcibly than in endeavouring to reduce to a minimum the liability to accident and the danger to life. That this Institution, by its constant interchange of ideas and the valuable papers periodically contributed by its members, will conduce to this end I firmly believe.

Mr. A. H. STOKES said he would like to propose a vote of thanks to the Chairman for his very valuable address. It appeared to be seventeen volumes condensed into seventeen sheets. It was a review of the work of the Institution. Every student or other person who was thinking of writing a paper would see from the address what a wide field he had for his labours. It was not only interesting, but there were many points touched upon well worth the attention and discussion of that Institution.

Mr. HENRY LEWIS said he had very great pleasure in seconding the vote of thanks proposed by Mr. Stokes. He was sure it was a very valuable address indeed, and he hoped the young members of the Institution would take the advice the President gave and come forward and write papers during the year.

The vote having been carried with acclamation,

The CHAIRMAN (Mr. Jackson) expressed his thanks for the encouragement given him at his first meeting. It was very pleasant to know that the few remarks he had put together had met with their approbation.

DISCUSSION ON MR. CHARLES SOAR'S PAPER ON "COAL-LOWERING ARRANGEMENTS AT GRANVILLE COLLIERY (SOAR'S PATENT)."

The CHAIRMAN said Mr. Soar's paper was open for discussion. The members had not an opportunity of reading the paper in time for the meeting, but he understood Mr. Soar was present, and would be able to answer any questions.

Mr. G. LEWIS said the cartoons, which were not before them at the last meeting, were now on the wall, and suggested that Mr. Soar should again explain the working of his apparatus.

Mr. CHARLES SOAR (Swadlincote) then proceeded to explain his drawings, remarking that his apparatus dealt with coal—cobbles and nuts—that had been screened.

Mr. H. LEWIS—What quantity are you doing?

Mr. SOAR—The collieries are not fully developed; at present we are passing 150 tons of cobbles.

Mr. H. LEWIS—What is the length of the band?

Mr. SOAR—Sixteen feet.

Mr. H. LEWIS—How much do you calculate to get over the band?

Mr. SOAR—We hope to get 250 tons of cobbles and 130 tons of nuts. We have two lowering arrangements at work—one for lowering nuts and the other for lowering cobbles.

Mr. G. LEWIS—Do we understand that the picking band is simply to convey the coal to the lowering apparatus?

Mr. SOAR—It is to enable the inferior coal and "bats" to be picked out. It then travels to the lowering apparatus, and instead of having to slide down a shoot the lowering arrangement catches it when in the act of falling off the picking band.

Mr. H. LEWIS—What is the width of the bars of the screens it comes over?

Mr. SOAR—They are shakers, not bars. We have meshes, and they vary according to the coal in demand. We can change them in a very few minutes.

Mr. J. A. LONGDEN said it appeared to him that Mr. Soar did not make the best of his apparatus. It seemed to him that they got along the band various kinds of coal. After they had picked off all the hand-picked qualities they were able to deal with 250 tons per day of smaller coal which still remained on the band. So that as a matter of fact, if the smaller coal falling over the end of the band was only 25 per cent. of the total output, that apparatus was capable of dealing with 1,000 tons a day.

Mr. G. S. BRAGGE (Swadlincote)—That is exactly so.

Mr. SOAR—The apparatus will put the coal in the trucks in the same condition as it leaves the screens.

Mr. H. LEWIS—When you commence to lower, you do not start as shown on the drawing?

Mr. SOAR—No; we start filling the truck at one end, and as the truck fills it is lowered down.

Mr. G. LEWIS—You require a separate lowering apparatus for each sort of coal?

Mr. SOAR—Yes; one for nuts and one for cobbles.

Mr. G. LEWIS—So that the remarks of Mr. Longden would not apply?

Mr. SOAR—No, sir. So far as relates to the sorting of the hand-picked qualities off the same belt as is used in connection with this apparatus. If the hand-picked coal is sorted out previously to screening, Mr. Longden's remarks would be quite correct—this system is in fact what we carry out.

Mr. G. LEWIS—You could, I presume, conduct coal from the screens into the hoppers of the lowering apparatus without a belt at all?

Mr. SOAR—It would be better, if without a picking band, to come straight on from the screens.

Mr. G. LEWIS—Then you simply use the belt to give facilities for picking off the inferior coal?

Mr. SOAR—Yes, and dirt.

Mr. G. LEWIS—Then supposing you had no necessity for the picking belt, you would pass the coal from the screens to the hoppers?

Mr. SOAR—Yes.

Mr. G. LEWIS—If that is so, what is the cost of the apparatus per wagon, one being necessary for each?

Mr. SOAR—The estimated cost of the apparatus is about £32.

Mr. H. LEWIS said, at the collieries he was connected with, when the coal left the screens to be delivered into the wagons, there was a large sheet of iron that lapped over into the wagon. The coal had something like 2 feet to fall. He, however, considered this an admirable arrangement if they had to deal with only a small quantity of coal; but he questioned, if six or seven hundred tons could be put upon that apparatus, whether they would be able to dispose of it.

Mr. SOAR—That is, to deal with tender coal—not hard coal. The apparatus will lower all the coal that passes along the belt.

Mr. H. LEWIS said his remarks would apply whether the coal was hard or soft.

Mr. SOAR—Quite so; there is no doubt about the apparatus being a saving.

Mr. T. A. SOUTHERN (H.M. Inspector of Mines, Derby) enquired whether the quantity of coal passing along the belt was limited by the capacity of the apparatus?

Mr. SOAR—It will take any quantity.

Mr. SOUTHERN—Its speed depends on the speed of the belt?

Mr. SOAR—Yes; it travels as fast as the belt by the chain driving-wheels.

Mr. G. HOWE (Clay Cross) said it seemed a very ingenious machine for tender coal. He could not see any difficulty in the working as shown on the drawing, but he would like to know how they changed the wagons?

Mr. SOAR explained that when the wagon was full the machine was raised, the scotch taken off the wagon, which moved down, and the apparatus was lowered again—not taking a moment. It was done in less time than it took him to describe it.

Mr. M. H. MILLS—How many men does it require to work it?

Mr. SOAR—One man—the superintendent of the screens; he can look after the belt and the lowering arrangements.

Mr. SOUTHERN—Does it not require almost constant attention?

Mr. SOAR—The man can walk backwards and forwards, and look after the boys that are picking "bats" off the belts.

Mr. STOKES said that the economical working of the machine was a question which perhaps Mr. Bragge could tell them something about.

Mr. G. S. BRAGGE (Swadlincote) could not say there was any appreciable economy in the working of it compared with ordinary screens, that is as regards the cost per ton of coal screened; but there was certainly a very great advantage in the use of it from the largely increased value of the coal. They were, unfortunately, working a very tender coal, which, when shot from the screens direct into the waggons, produced so much dust that the screenings were almost unsaleable. Since adopting this machine they had had a greatly increased value in their coal; so that, although he could not say there was any economy in the working, the results of the colliery were very much better. He could bear out what Mr. Soar said, that no special attention was required for the lowering arrangement, so that the cost of screening had not been *increased* by its adoption. The man who superintended the

screening and looked after the lads at the belts attended to the lowering machine. They were dealing with 300 tons a day, and he had no doubt they would be able to do more as their output increased.

The CHAIRMAN said he did not propose to close the discussion that day, because the paper had not yet been in the hands of the members, and there were other matters they might like to ask questions upon. He would therefore suggest that they adjourn the further consideration of the paper.

Mr. G. HOWE said he would like to ask how the apparatus would work without a belt? In that case, instead of the coal going on from the end of the wagon it would go on broadside.

Mr. SOAR—It would make no difference. You must have it in the middle of the wagon.

Mr. G. HOWE—You would carry it the same way as the screens?

Mr. SOAR—Yes.

Mr. H. LEWIS seconded the Chairman's proposal, and it was agreed to.

DISCUSSION ON IMPROVED COAL SCREENING AND CLEANING, ETC.

The CHAIRMAN said the next subject for discussion was "Any or all of the papers of the Federated Institution of Mining Engineers." They had had these papers before them and probably some gentleman would have some remarks to make upon them.

Mr. J. A. LONGDEN said he intended to have said previously in reference to the Federated Institution that he thought the 15s. a year they paid was extremely well spent money, and nothing would help to maintain their Institute as an Institute better than the fact that the members receive the Transactions of other institutes in addition to their own. He was afraid he must say that so far as the last six or nine months were concerned, the papers they had received from the other institutes were far more valuable than those they had themselves contributed to the Federated Institution. He thought the paper of Messrs. T. E. Forster and H. Ayton on "Improved Coal Screening and Cleaning" one of the best papers he had seen on that subject. The detailed information they had given as to belts was very great. Those who were practically acquainted with belts could appreciate the amount of work which was put into that paper. One point he would rather like to draw the writers' attention to, and that was that they did not say anything as regards the total economy. They did not say what was the cost of banking before the adoption of the belt, and what it was afterwards, taking sales and wages into account. He had had a rather curious experience during the last few months, and one that he was not quite prepared for, and it might mean a very serious drawback to belts. At a colliery with which he was connected, a belt had lately been put up, and a very considerable saving might have been expected; but instead of that they had found an increased quantity of slack produced from the coal falling three times: firstly, from the tipper on to the belt; secondly, from the belt on to the elevator; and thirdly, from the elevator into the screen. This reduction of coal into slack more than compensated for any saving in wages through putting up the belt. It seemed a very serious thing, and he would like very much to know what Mr. Forster found out, because he knew that at those collieries the belt had displaced screens, and therefore the difference could be ascertained easily. The small coal now had to be tipped three times, whereas with the old method of handing out of tubs it only had to be tipped once. He did not say that the belt had been a failure,

because it had not; the improved condition of the coal was a great advantage now, owing to the imperfect sorting in the past. He had found a great advantage in the increased selling price of the coal since the belt was adopted, but it could not answer everywhere. If a belt was erected where there was no question of sorting, and as a consequence there was a large increase in the quantity of slack, it would not be a profitable investment. This was quite a new experience to him, although he had had to do with belts many years with various coals, and he thought it deserved attention.

Mr. J. W. EARDLEY (Alfreton) said that with reference to Mr. Longden's statement as to the coal being turned over three times, he thought Mr. Soar's arrangement would obviate that. Since the last meeting he had been over to Granville Colliery, and looked at Mr. Soar's apparatus, and he thought it would save the three times tipping of the coal. In this case, the coal was tipped on to the screens, and the nuts and slack taken out; the remainder passed on to the travelling belts, and was then received by the lowering apparatus, as shown by the drawings.

Mr. G. LEWIS said the question of tipping coal and banking it was a much more difficult question, and required their attention to a greater extent than had previously been the case in their discussions. They all knew from experience that a piece of coal could not be dropped from a tub and placed on the screen without breaking off the corners and making small to some extent; and banking coal, to his mind, was a very difficult matter to arrange satisfactorily. Sorting belts were a very valuable assistance, and reduced the cost, but they were certainly the cause of a quantity of dust being made by passing over the small pieces of coal in transit. He had seen belts which had made much more small than others; but this was the fault of the makers, and was not owing to the principle upon which they were constructed. With care, the points alluded to by Mr. Longden could be to a great extent remedied. Mr. Soar's apparatus, to some extent, pointed out the way, and would prove a very useful assistance. What they wanted was a really good tipping machine to commence with. He had never seen one suitable for the Midland districts yet. The problem still required solving, and he thought would be accomplished by one of their members. In districts where they worked small tubs holding from three to four cwt. of coal, and simply loaded level, it was easily arranged; but coming into their own district, where the tubs held fourteen or fifteen cwt., and loaded very much above the top, they had a difficulty to contend with, and a certain amount of breakage could not, he was afraid, be avoided. If they could have any light thrown on the subject it would be very desirable; personally, he had never yet seen a really successful tipper.

Mr. A. H. STOKES said there was undoubtedly a great deal in the question of coal tipping and sorting. Did Mr. Lewis use side or front tippers?

Mr. G. LEWIS—I have tried both ways.

Mr. STOKES said some tipped right over. If they did so they would break the coal. Others tipped sideways, and others back over, which appeared to be the best way of tipping a tender coal. Mr. Longden did not tell them, when he mentioned the increase of slack, what was the increase of best coal he obtained by the belt arrangement. With the old tub arrangement it was easy to leave a quantity of best coal at the bottom. What he wanted to know was the increased percentage of best coal obtained as compared with the increased slack. If they got an increase of 3 per cent. of slack, it was only equal to an increase of 1 per cent. of best coal, taking the price of best coal as equal to three times as much as slack——

Mr. G. LEWIS—It was best coal before it was broken.

Mr. STOKES (continuing) said if they got an increase of 1 per cent. in large coal and 3 per cent. in slack the result was the same as before the belt was put down.

They must consider this, as well as the fact that they were getting a large quantity loaded with a belt, before they condemned the belts. He did not know a subject of more economic importance than the loading and screening of coal.

Mr. G. LEWIS repeated his former observation that the slack was best coal before it was broken, and remarked that it was therefore not the price of slack they had to consider, but the difference in price between what would have been best coal and slack. He had fully tested the advantages of the sorting belt, and he did not think they had any wish to detract from its advantages. He believed it to be a very valuable machine, and it gave them an opportunity of sorting and cleaning the coal which could not possibly be done by the old method of taking it direct from the tubs; but it certainly produced a greater percentage of dust than had been the case under the old system.

Mr. GEORGE HEWITT (Unstone) remarked that they had a belt and a jigger screen. He did not find any more breakage from this than from the old screens; the slack from the belt and jigger screen with the same sized mesh was less than from the old-fashioned screen bars.

Mr. H. LEWIS said he could give Mr. G. Lewis and Mr. Longden a wrinkle. They should look after the loading of the coal in the pit.

Mr. G. LEWIS said he took the slack out before it came to the top.

The CHAIRMAN asked if any other gentleman had anything to say.

Mr. A. H. STOKES said as to future papers and the question of expense, if all the papers were published in the form he had in his hand—in small type—less expense would be entailed.

Mr. M. H. MILLS, in reply to Mr. Stokes, said it could hardly be estimated what the actual expense of publishing for the Federated Institution was. They at present were only feeling their way, and he hoped at the end of this year to be able to say something as to what the actual expense would be. At present he did not think they could say one or another system was the best or least expensive.

The CHAIRMAN endorsed the remarks of previous speakers as to the importance of the question of screening, etc. Every year more coal would be required, and therefore every year more coal would have to be got, and they would have to endeavour not to leave the smallest quantity of coal in the pit. Instead of having five or six kinds of coal, they would very likely have ten or twelve, and each would have its uses. With regard to Mr. Longden's remarks, there had been some reduction of cost made, for Messrs. Forster and Ayton in their paper stated:—"The saving under ordinary circumstances may be estimated at a ½d. or ¾d. per ton on the gross output." As to the tipping of the coal being done three times, it looked as if there was a saving in Mr. Soar's arrangement, as the coal was deposited on the platform and then into the wagon, and there it rested; so there was diminution of breakage in that respect. There were now about half a dozen tippers, and opinions varied on their merits; but no tipper placed the coal on the screens without causing breakage. This was a most important matter, and if mechanical engineers would set their brains to work and invent something that would supersede anything they had as yet got, it would be a great benefit to those districts especially where very tender coal was produced.

MEMOIR OF A DECEASED MEMBER.

Joseph Timms was born at Stoneyford, near Langley Mill, Derbyshire, on the 15th of November, 1816. His father's death occurring somewhat suddenly, left a widow and three children unprovided for, of whom Joseph, the eldest, and a younger brother, were obliged to leave school to work. From this time he was chiefly employed amongst engines; and when still very young, he became engine-wright at Stoneyford.

In 1845 he and his brother, also an engine-wright, removed to Chesterfield. Here he attended a night school, taught alternately by Mr. Booker, a private schoolmaster, and the Rev. F. Calder, M.A., head master of the Chesterfield Grammar School. His chief study was mathematics, in which, being an apt scholar, he received much encouragement—from Mr. Calder in particular. Here, also, he joined the Wesleyan Society, and became a Sunday school teacher.

After residing about ten years in Chesterfield he removed to the lovely village of Milltown, Ashover, where the beautiful scenery, fresh air, and pure water could not fail to be appreciated by one of his quiet mind. About ten years later the Lead Ore Mines being set down he was no longer needed as engineman there.

In April, 1864, he was, on the recommendation of Mr. Hedley, engaged by Mr. Worswick, then about to commence the present Annesley Colliery, Nottinghamshire. There he remained nearly ten years, until Mr. Henry Lewis, the manager at Annesley, transferred his services to the new colliery he was about to establish at Linby, in the same district.

He became a member of the Chesterfield and Derbyshire Institute in April, 1881, and in the same year read a paper on, and took a leading part in discussing, the question of "Compressed Air as a Transmitter of Power." On several other subjects he contributed in discussion the results of his experience and calculations. His most recent paper was given to the Institution in January, 1888, on "Past and Present Methods of Banking Coal at Annesley."

The subject of this memoir was of a strong constitution, and was scarcely ever ill up to the last two and a half years before his death, when his health failed. His anxious desire for knowledge, and the difficulty he had in obtaining that knowledge when young, made a great impression on his naturally kind heart, and gave him a fellow-feeling for others placed in similar circumstances; so that, in after-life, any young man seeking information on any subject found him ever ready to assist so far as lay in his power. His retiring disposition, natural reserve, strict integrity, and rigid adherence to the truth, sometimes made him appear to disadvantage; but underneath all lay one of the most humble, sincere, and generous of souls, ever willing to learn, and ever ready to impart to others.

He died January 20th, 1890, aged 73 years and 2 months, and was interred at Langley Mill Baptist Chapel.

The CHAIRMAN said that the last item on the agenda paper was Mr. Maurice Deacon's paper, "Comparative Experiments upon a Capell and a Schiele Fan working under similar conditions." This paper had been approved of by the Papers' Inspection Committee, and in due time would be printed. He therefore thought it had better be taken as read.

COMPARATIVE EXPERIMENTS UPON A CAPELL AND A SCHIELE FAN WORKING UNDER SIMILAR CONDITIONS.

By Maurice Deacon.

An opportunity of testing fans of different descriptions working upon the same air-ways, shafts, and drift, and driven by the same engine, so seldom occurs, that the writer offers the following notes in the hope that they may be of some interest to the members of this Institute :—

The fans upon which the tests were made are working at the Shirland Colliery, owned by the Blackwell Colliery Company, Limited.

When the colliery was acquired by the Blackwell Colliery Company, about a year and a half ago, the fan in use was a 5 foot Schiele, driven by a 15 inch × 24 inch engine.

The quantity of air produced by this fan and the economical results being unsatisfactory, a 12 feet 6 inch Capell fan, and an 18 inch × 24 inch engine were put down, and so arranged that either the Capell or the Schiele fan could be driven by either of the engines. The arrangement of fans, engines, and drifts will be understood on reference to Plate I.

Description of Fans.—The following are the dimensions of the two fans :—

Description of Fan.	Diameter.	Width of Wings. At Inlet.	Width of Wings. At Tips.	Diameter of Inlets.	Casings	Chimneys. Area at Base.	Chimneys. Area at Top.	Chimneys. Height.
	Ft. In.	Ft. In.	Ft. In.	Ft. In.		Ft. In.	Ft. In.	Ft. In.
Schiele ..	5 0	1 3	0 10	2 10 Double	Wrought Iron	12 3	12 3	1 10
Capell ...	12 6	5 8	5 8	7 4 Single	Steel Plate ...	55 3	126 6	10 0

Engine.—The tests were made with the 18 inch diameter × 24 inch stroke high pressure engine, with slide valve, and no expansion gear. The Schiele fan is geared 6·15 to 1, and the Capell 2¼ to 1. Both fans are driven off the fly-wheel by a 12 inch double-ply leather belt, which can be applied to either fan without altering its length.

Water-gauge.—For the purpose of fixing the water-gauge in an average position in the inlet, some rough experiments were made with the following results, the Capell fan running at 174 revolutions per minute the whole time. In all the experiments the tube was held 12 inches from the inlet :—

No. of Experiment.	Position of Water-gauge Tube.	Direction of Orifice of Tube.	Water-gauge.
1	27 inches above Fan Shaft	Across the air-current	2·50
2	Do. do.	Against do. do.	2·25
3	Do. do.	Same direction as do.	2·25
4	12 inches from Fan Shaft horizontally	Across the air-current	2·52
5	Do. do.	Against do. do.	2·20
6	Do. do.	Same direction as do.	2·50
7	18 inches from Fan Shaft horizontally	Across the air-current	2·55
8	Do. do.	Against do. do.	2·30
9	Do. do.	Same direction as do.	2·60
10	1 inch from edge of Inlet	Across the air-current	2·40
11	Do. do.	Against do. do.	2·30
12	Do. do.	Same direction as do.	2·50

The above results do not show as much variation as might be expected, but the fact of the fan pit, up which the air ascends from the drift, being close to the inlet may to some extent account for this, the air-current not having a straight run to the fan.

The water-gauge was fixed (with padded end) for the fan tests in position No. 3, viz., 27 inches over the top of the fan shaft, with the orifice turned in the same direction as the air-current, and in the same relative position for the Schiele tests.

Measurement of Air.—The air was measured in the fan drift at the point A in the case of the Schiele, and at B in the case of the Capell. The drift was in each case divided into sixteen spaces by means of strings stretched vertically and horizontally across the drift, and the air was measured for one minute in each space by two anemometers, the mean readings of the two being taken as the correct velocity. The anemometers were a 6 inch and a 4 inch, both of the Biram type, and specially tested for these experiments by Messrs. John Davis & Son in the writer's presence.

Indicating.—The engine was indicated whilst the air was being measured. A Richard's indicator, with springs specially tested for these experiments, was used. The diagrams are shown on Plate II.

The first comparative experiments were tried with both fans, producing 1 inch water-gauge.

The second experiments were tried with equal periphery speeds.

In the experiments shown in the annexed table, the wide difference between the water-gauge in fan drift and in pit is to be largely accounted for by the fact that the upcast is blocked with pump rods, rising mains, and steam pipes.

The horse-power required to drive the engine alone at 84 revolutions (which gives 209 revolutions of the Capell fan) was 6·21 horse-power, which is equal to 6·1 per cent. of the total power exerted with fan running.

The actual output of the Capell fan, as compared with its theoretical capacity, is very high. In some Guibal fans which have come under the writer's notice, this does not exceed 15 per cent. to 20 per cent.

The results generally of the Capell fan tests are so good that it is not necessary to do more than refer to the table.

The column stating fuel consumed per horse-power per hour *in the air* shows the relative economical results of the two fans at a glance.

As to cost of plant, the Capell fan, 18 inch engine, and cost of fixing, was under £650; and the cost of fan house was under £100. Including fan pit and drift, the total cost of the whole plant was under £900.

Some experiments were also made upon the natural ventilation of the mine (assisted by the heat of steam pipes in the upcast), with the upcast doors open, and the fans standing; and also with steam jets, which were once upon a time used when the fan was stopped from any cause, and which still remain attached to the steam pipes in the upcast.

EXPERIMENTS UPON NATURAL VENTILATION, AND WITH STEAM JETS.

	Depth of Pits.		Diameter of Pits.		Barometer.		Thermometer.		Water-gauge at Separation Doors.	Velocity of Air.	Volume of Air per Minute.	H.P. in Air.
	Downcast.	Upcast.	Downcast.	Upcast.	Surface.	Pit.	Downcast.	Upcast.				
	Yds.	Yds.	Feet.	Feet.	Inches.	Inches.	°	°	Inch.	Feet	Cub. Ft.	
Natural Ventilation	158	158	12	12	29·07	29·56	48	72	·2	369	28,339	·89
Steam Jets	158	158	12	12	29·7	30·19	65	86	·25	303 495	33,962	1·3

TABLE SHOWING THE RESULTS OF THE COMPARATIVE EXPERIMENTS, AS WELL AS SOME TESTS MADE UPON THE CAPELL FAN AT SPEEDS BEYOND COMPARISON WITH THE SCHIELE.

Number of Test.	Fan.	Barometer on Surface.	Thermometer on Surface.	Thermometer in Drift.	Revolutions per Minute of Fan.	Periphery Speed in Feet per Second.	Area of Drift in Sq. Feet.	Mean Velocity of Air in Feet per Minute.	Volume of Air in Cubic Feet per Minute.	Water-gauge in Drift.	Water-gauge in Pit at Separation Doors.	Horse-power in the Air.	Mean Steam Pressure in Cylinder in Lbs.	Revolutions per Minute of Engine.	I.H.P. of Engine.	Useful Effect of Steam used per Cent.	Proportion of Output to Body Capacity of Fan.	Calculated Tons of Slack used per Week.	Fuel Consumed per I.H.P. of Engine per Hour.	Fuel Consumed per Horse-power in Air per Hour.	Cost of Fuel per Week at 3s. per Ton. £	s.	d.
		Inches.								Inches	Inches								Lbs.	Lbs.	£	s.	d.
1	Capell.........	29·36	60	66	110	71·9	83·8	717	60,084	1	·7	9·46	11·95	44	15·9	59·5	79·5	11·8	9·9	15·7	1	15	6
1*a*	Schiele	29·9	58	69	427	111·7	76·8	569	43,699	1	·45	6·91	12·2	70	25·61	26·98	...	9·1	9·9	36·8	2	17	3
2	Capell.........	29·36	60	66	195	127·6	83·8	1 411	118,241	3·25	1·8	60·5	36·5	78	87·4	69·2	88·2	64·1	9·9	11·5	9	12	3
2*a*	Schiele........	29·9	60	69	488	127·6	76·8	670	51,456	1·45	·55	11·75	15·37	80	39·86	29·48	...	29·7	9·9	33·7	4	9	0
3	Capell	...	...	...	209	136·7	83·8	1,434	120,169	3·7	...	70·7	40·17	84	101·8	69·4	83·6	75·9	9·9	14·9	11	7	6
4	Capell	29·7	67	...	212½	138·8	83·8	1,456	122,012	3·85	2·0	74·02	40·5	85	102·8	72·0	83·5	76·2	9·9	13·5	11	8	6
5	Capell	29·4	69	66	197	128·7	83·8	1,438	120,600	3·00	...	57·01	35·5	79	85·31	66·8	88·3	63·6	9·9	14·8	9	10	9
6	Capell.........	29·36	...	...	216	141·1	83·8	1,470	123.186	3·8	...	73·7	39·98	88	107·6	68·5	83·0	79·2	9·9	14·3	11	17	6

Cost of Oil, Waste, etc., per Week: —

	s.	d.
Capell fan, at 150 revolutions per minute (73,000 cubic feet of air)	1	10½
Schiele fan, at 553 revolutions per minute (52,000 cubic feet of air)	2	4½

Mr. J. A. Longden thought they ought to pass a hearty vote of thanks to their retiring President. They would observe there was a reference made by the Council in their report to the fact that Mr. George Lewis during the last year had attended every General Meeting and nearly every Council Meeting, no doubt at very considerable inconvenience to himself. His generous treatment of the Institute at Manchester was not forgotten, and he was glad he had been able to attend so well to the duties of his office and set such a good example. He only hoped his great desire with regard to additional papers would be fulfilled, and so the Institute become as it should be, a very flourishing society in the future. He had much pleasure in proposing that the best thanks of the Institution be presented to Mr. George Lewis for the manner in which he had filled the position of President for the year 1889-90.

Mr. M. H. Mills had very great pleasure in seconding the vote. As a member of the Council he could say that Mr. Lewis was most assiduous in attendance, and not only had he presided at the meetings but he had taken a lively interest in everything that was connected with the Institution, and thus set an example for many other members to try and make the Institution more useful.

The resolution was carried amid applause.

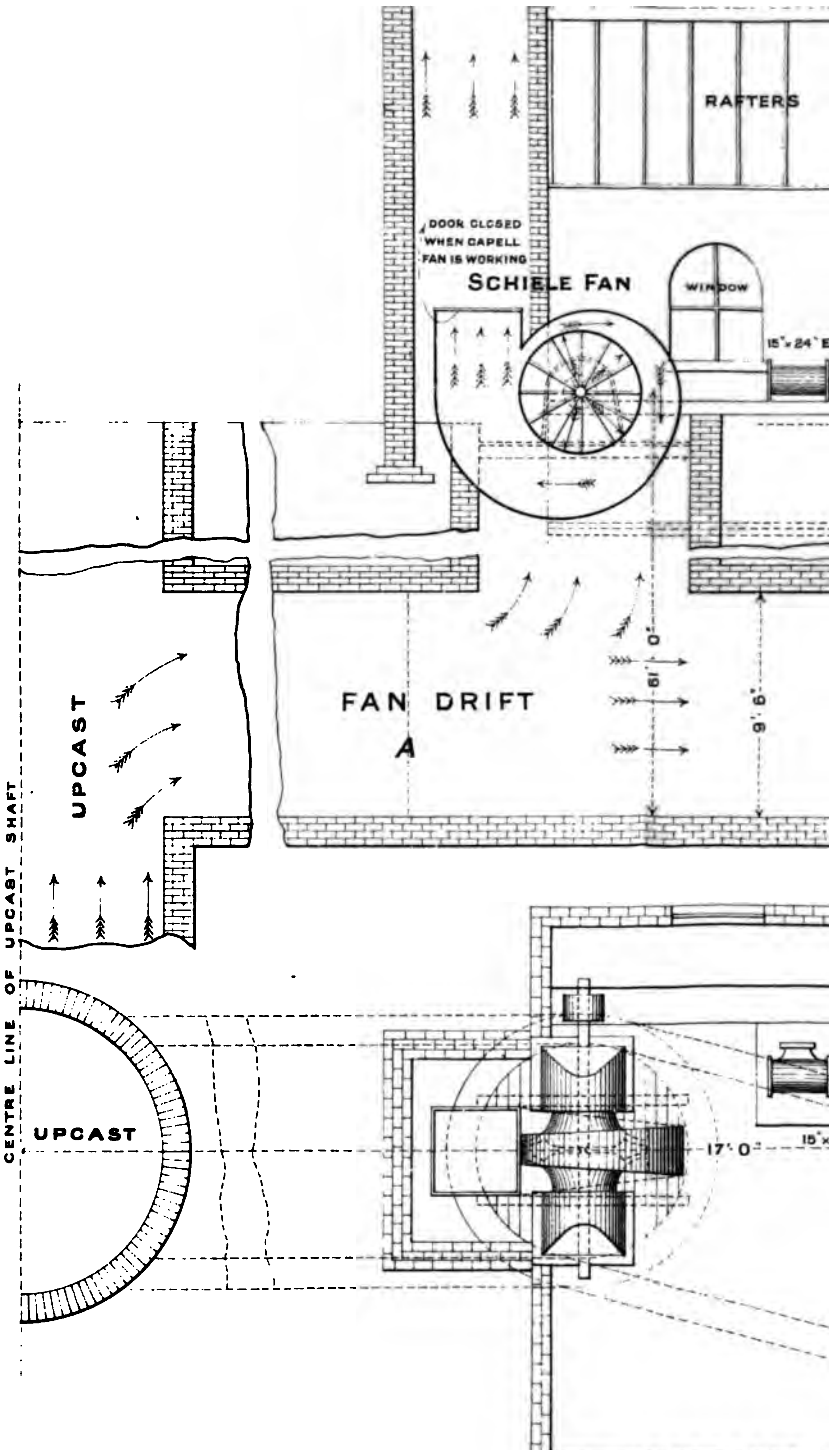
Mr. G. Lewis said he was very much obliged for the very cordial vote of thanks they had accorded to him; and if he had been of any service he could assure them it had been a pleasure to him to preside at their meetings. He hoped in the future not to become a dormant member, but still to have the pleasure of attending their meetings, and if he could in any way assist the Institute or any member he should be pleased to do so.

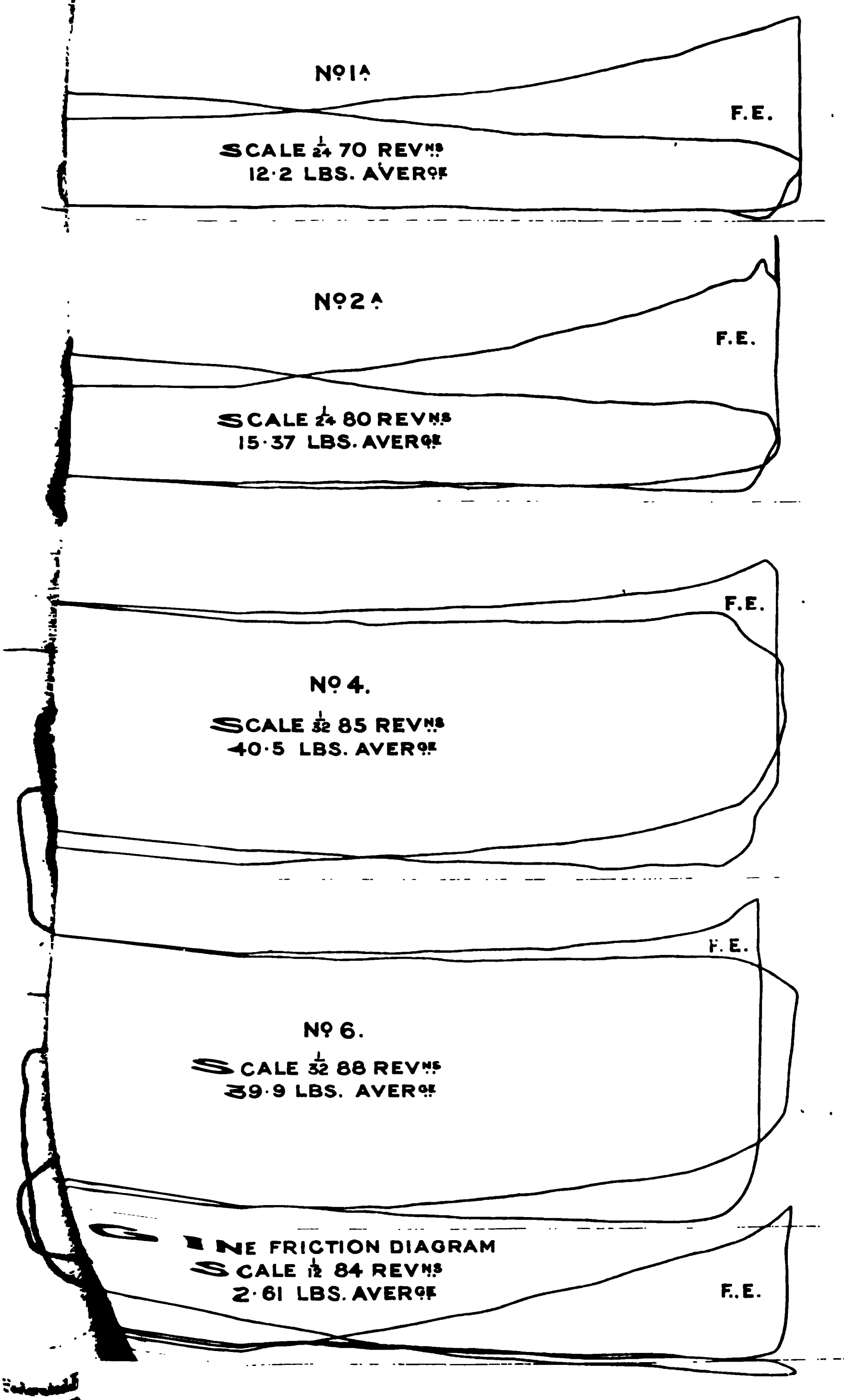
Mr. H. Lewis proposed, and Mr. G. Lewis seconded, a vote of thanks to the Chairman, the latter remarking that he was sure they had put the right man in the right place.

The Chairman only hoped they would be of the same opinion at the end of the year.

The members then adjourned and dined together at the Station Hotel.

To illustrate Mr. Deacon's paper on "Comp
working un




No 1A
F.E.
SCALE 1/24 70 REVns
12·2 LBS. AVERge
No 2A
F.E.
SCALE 1/24 80 REVns
15·37 LBS. AVERge
F.E.
No 4.
SCALE 1/32 85 REVns
40·5 LBS. AVERge
F.E.
No 6.
SCALE 1/32 88 REVns
39·9 LBS. AVERge
NE FRICTION DIAGRAM
SCALE 1/12 84 REVns
2·61 LBS. AVERge
F.E.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, ON SATURDAY, APRIL 12TH, 1890.

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The PRESIDENT said that the minutes of the last meeting could not be read, and the proceedings of the Council could not be reported, owing to the absence of the Secretary (Professor Lebour) through illness.

The following gentlemen were elected, having been previously nominated :—

MEMBER—

Mr. Hiram Craven, Jun., Mechanical Engineer, Sunderland.

ASSOCIATE—

Mr. Edgar Ormerod Bolton, Mining Engineer, Executors of Colonel Hargreaves, Burnley.

The following gentlemen were nominated for election :—

MEMBERS—

Mr. C. H. Eden, Mining Engineer, Old Etherley.
Mr. Leonard Francis Gillett, Mining Engineer, Derby.
Mr. W. H. F. Maddison, Mining Engineer, The Lindens, Darlington.

ASSOCIATE—

Mr. John William Fryar, Mining Student, Seghill Colliery, Seghill, Northumberland.

A paper by Mr. W. RAMSAY on "Ramsay's Patent Improved Levelling Staff for use in Mines" was read.

RAMSAY'S PATENT IMPROVED LEVELLING STAFF FOR USE IN MINES.

By W. Ramsay.

Various kinds of levelling staves are described in treatises, but few of them have been found to be practically applicable to general use for mining purposes.

The old construction, the non-speaking staff, has many adherents, although the observations are recorded by an assistant required to possess sufficient intelligence to be trusted with the responsible duty of recording the results.

With the speaking staff, if the sights exceed a very limited distance, the observer soon begins to experience difficulty in reading the figures through the telescope.

This difficulty arises from many causes: it may be from moisture or dust in the air, indistinctness in the graduated face of the staff, and most frequently from the difficulty of illuminating the face of the staff with a miner's lamp.

The writer, in consequence of these difficulties, has devised an arrangement which he believes will prove useful in practice.

The staff is formed after any of the ordinary constructions, except the part *a* (Plate I.) carrying the scale, which is formed of any transparent material, such as white opal glass, with a ground or enamelled surface. The staff consists of two parts, *b* and *c*, which are packed together by sliding, and when drawn out for use form a staff of convenient length.

The divisions are placed upon the transparent surface with any opaque colours, so that when a lamp or other source of light is held behind the staff, the reading can be distinctly observed at considerable distances through the telescope by the surveyor.

Comparative trials with the staves, side by side, have shown that using the same telescope the improved staff is read with ease when a speaking staff of the ordinary construction is read with difficulty, or even cannot be read at all.

The improved staff is read with facility where an ordinary staff could only be read by means of an improvised vane placed in front of it.

With the improved staff all chance of error in the readings is eliminated, except on the part of the observer himself. Further, there is the advantage that the lamp placed behind the staff illuminates nearly the whole of the scale, and the observer can, in most cases, take his reading without any alteration in the position of the light.

The advantages as regards accuracy and saving of time are so great, by the use of the improved transparent levelling staff over those of the old constructions, that the writer believes that its universal adoption will be ensured.

The President asked Mr. W. Ramsay, who was present, to exhibit the staff and explain its advantages.

Mr. Ramsay said he found, from experience, that mistakes were frequently made in the readings with the old style of staff. When working at a distance the man at the staff was frequently told to run his finger along the staff, and the surveyor called to him to stop and read off the figures; if there was a mistake the responsibility always fell on the man at the staff. With the staff just described, the figures could be plainly read by the surveyor, when a light was placed behind the transparent staff, the figures being painted with opaque pigment on a white background of frosted glass or other transparent material. The operator is able to make his own readings, under all circumstances, when used underground, or on dark nights.

Mr. W. LISHMAN (Witton) said that such a staff must prove very useful, and especially for underground work, where its use appeared to enhance the accuracy of the results.

Mr. W. RAMSAY then explained the sliding arrangement, by which the staff could be used in seams varying from 3 to nearly 6 feet in height. The staff has been in use for nearly a year, and he found that the work could be done with it in about one-third of the time required with the old staff.

Mr. T. W. BENSON said the usefulness of the staff was not to be judged by the length of the paper; it would be extremely useful. He knew, from recollections of the time when he had to take levellings himself, that there was nothing more tedious than making a levelling down the pit, and from the description of Mr. Ramsay's staff he thought it would enable a surveyor to do his work in very much less time, and, instead of being dependent upon the assistant, he would make his own readings, which was a very important advantage. He did not think they should deprecate the reading of short papers; they were probably of more practical value than those occupying more space, and it was with much pleasure that he proposed that the thanks of the Institute should be given to Mr. Ramsay. It was not a staff essentially for underground use; he thought it would have proved very useful fifty years ago to those who made flying surveys at night for projected railways at the risk of having men with pitchforks after them.

Mr. M. WALTON BROWN said he had great pleasure in seconding the vote of thanks to Mr. Ramsay. He had seen the staff in use, and it was incomparably superior to the ordinary staff, owing to the clearness with which the readings were made; when seen in use, its value was at once appreciated. There was a great difference between the use of the new staff and the old one; with the new staff, a light placed behind it was sufficient.

The PRESIDENT asked if it was necessary to raise or lower the light to take readings of the first three feet?

Mr. RAMSAY said it was not necessary; a light placed behind the staff illuminated its whole length.

Mr. BLACKETT thought that for use in the daylight it would be better than the old white painted staff with black figures.

The PRESIDENT agreed with Mr. Blackett, but he thought the light from behind was an advantage.

Mr. C. C. LEACH asked if the red figures showed clearly with the light behind, and also how many staffs he had broken?

Mr. RAMSAY said the figures showed clearly with a light behind, and that he had not broken a staff; if a man had one of these staves he would be careful, and ordinarily there was not much risk of breakage. (He showed the tin case in which the staff was carried.)

The PRESIDENT asked the weight of the staff, and who was the maker?

Mr. RAMSAY said that the weight was about 1¼ lbs., and about 3 lbs. inclusive of case; Mr. T. B. Winter made it.

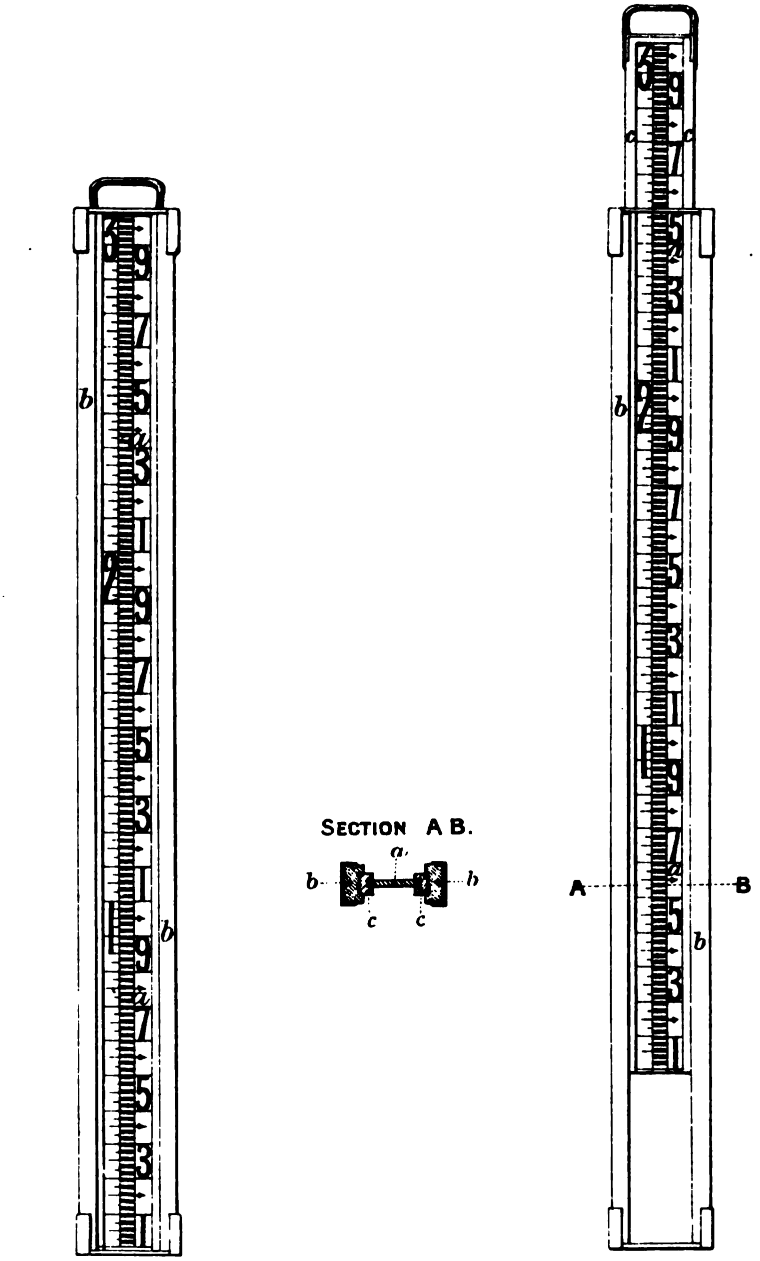
Mr. ELWEN asked if dust and dirt would have any effect upon the figures.

Mr. RAMSAY—Not the least, it is glass on both sides, and can be freely cleaned with water.

The PRESIDENT invited the members to handle and examine the staff. Levelling was one of those practical matters which they had to deal with daily, and the staff was most valuable if they performed a levelling with it in one-third of the time occupied with the ordinary staff, and more especially if the work was done without the necessity of bullying the staff-holder.

Mr. LEACH asked if Mr. Ramsay had noted the greatest distance at which the staff could be used?

To illustrate Mr. W. Ramsay's paper on "Ramsay's Patent Improved Levelling Staff for Use in Mines."



...ated Institution of Mining Engineers
Proceedings 1889-9..

Andw Reid Sons & Co Lithos Newcastle.

The PRESIDENT thought that this distance would depend a good deal on the power of the telescope used. What was the general length of the sets between the telescope and the staff?

Mr. RAMSAY said they had taken very long sights, and had experienced no difficulty in making the readings. It was perfectly clear at a distance of 100 yards in the dark with a light behind the staff, but this of course depends upon the power of the telescope used.

The vote of thanks to Mr. Ramsay for his paper was unanimously agreed to.

The PRESIDENT then stated that one of their Vice-Presidents, Mr. A. L. Steavenson, who had been visiting some parts of Spain, would make some remarks on his visit, and illustrate them by photographs, adding a few words on the advantage of photography to the mining engineer.

ON THE VALUE OF PHOTOGRAPHY TO MINING ENGINEERS.

Mr. A. L. STEAVENSON said that about two months ago he received instructions to visit a mining property in Spain. He started with a friend, journeying first to London and Paris, next day to Bordeaux, where they met with the mosquitoes, and the following day to Bilbao, which they reached at five o'clock, the fourth night of a long but very interesting journey. At Bilbao they met with a friend who could speak Spanish, and was acquainted with different matters of interest connected with mining, knowing the different mines and their values, and without the advantage of his company it would have been a very difficult matter to complete their business. The first day was devoted to seeing the shipment of ore, and in order to realise what they saw and to bring home some little information for his friends he had taken with him a small camera.

The ore was shipped in steamers, and he was told there were at that time about 200 steamers waiting for ore. (Photographs exhibited.)

In the afternoon they went to one of the mines, adjacent to Bilbao, and not more than a mile and a half distant, and found the ore being carted in ox-carts, down roads about two feet deep in mud.

In some cases they found the ore being brought down by wire-rope tramways. He did not know whether the members present had seen any of these tramways at work; the ropes were run at a considerable speed, and carried boxes containing from 7 to 8 cwt. of ore. (Photographs exhibited.)

The following day, in order to make themselves acquainted with peculiarities of the ore, and to see a really good mine, they went to the Orconera mine or quarry. (Photographs exhibited.) They found that immense deposits of ore were being worked. The deposit was from 40 to 50 feet thick, and he believed that they had other 40 or 50 feet below that. After separating about 10 per cent. of dirt, the residue contained 50 per cent. of iron, and they had no chance of competing with that in England, if it were not for the distance from this country and fuel.

In one mode of shipping (photograph exhibited) a spout was lowered towards the ship, and a trunk lowered to the bottom of the hold; this photograph was taken at six p.m., when the light was not very good, but it showed the details of the machinery.

Before reaching the mines they had been deputed to visit, they went to a branch railway station and stayed at a little hotel, so as to make an early start the next morning. Carriages were ordered for seven a.m., but when they got up a heavy

snowstorm was raging, and they were told it was impossible to think of going to the mountains, either that or the next day. They considered the best thing they could do was to go away to some cathedral town, where there would be something to see and better accommodation than in a country railway station hotel; and they went to see one of the finest cathedrals in the world—Burgos—(photograph exhibited) and stayed there until they received a telegram saying the mountains were clear of snow.

In going up the mountains, of considerable height, they had the pleasure of seeing eagles soaring above them, an opportunity not often met with in England.

On the hill side they found the deposit they had gone to inspect; it extended for some distance. (Photograph exhibited.) The deposit was a curious one, and, as far as they could see, it was neither a lode nor stratified.

From the average of some eleven or twelve bore-holes the thickness of the ore did not amount to more than 10 yards, but it extended from the top of the hill to the bottom, a distance of about 300 yards, and perhaps 200 yards wide. He had never seen anything of the kind before; the deposit appeared as if it had been simply poured over the side of the hill. People who understood the geology of the district said it was a cretaceous formation, and was really a deposit of iron from a hot spring.

He took one or two photographs of the style of houses, and it would be seen that the cattle were housed below, in the bottom part of the houses, the people living above. (Photograph of roadside hotel exhibited.)

He would just take the opportunity of pointing out the advantages of a knowledge of photography to engineers, more especially as there were a number of young members present. For the purpose of taking the photographs submitted, everything required could be carried on a long day's walk, and there was the advantage of obtaining views of not only matters of interest to oneself but to others who could not or did not go to see them. The negatives being obtained, copies could be printed off to the number desired, and any of the photographs exhibited to them could be enlarged to the size of the diagram on the wall.

Mr. STEAVENSON said after exhibiting a few more photographs, that if anyone wished to ask any questions he would be pleased to answer them.

The PRESIDENT said they were greatly obliged to Mr. Steavenson for bringing forward such a useful and interesting subject, and invited discussion.

Mr. W. J. BIRD asked if there was, in Mr. Steavenson's opinion, any foundation for the idea, more or less prevalent, that the richer ores of the Bilbao district were approaching exhaustion, and the average richness of the ore was now diminished?

The PRESIDENT said he had been over the mines referred to by Mr. Steavenson and, therefore, appreciated his remarks. Did Mr. Bird apply his question to vena, rubio, campanil, or the ores generally?

Mr. A. L. STEAVENSON said that the existing mines were exhausting the best of the ore; but in a large district of an area equal to that of the county of Northumberland, when one hill of ore was exhausted they might find another by looking for it; although they were exhausting the known supply, they were perhaps not exhausting the available supply. There was one thing, they had to go further inland for fresh supplies, and future workings would have to bear the cost of longer railway carriage. The mine railways were very simply made, and the cost of carriage by rail would be very much the same as in this country, except that fuel was a little dearer. The oxen carried loads of about two tons in carts; they were very powerful animals and travelled very slowly, but it was disgraceful to see the roads they had to travel.

Mr. Blackett said he could corroborate Mr. Steavenson's remarks as to the great value of photography to mining engineers, he had found it extremely useful as a means of providing evidence of anything which was likely to change, or about which evidence might be valuable in the future. It was almost as easy now to take photographs underground as on the surface. He would like to compliment Mr. Steavenson on the excellence of his photographs, which spoke highly of his ability as a photographer.

Mr. W. Lishman (Witton) said they were all very much obliged to Mr. Steavenson for his remarks, and asked what kind of light was required for photographing underground?

Mr. Blackett said he thought the magnesium light was the best.

Mr. Steavenson said, while he was speaking of the advantages of photography, he would add a word or two about underground photography. He had on two or three occasions tried to take photographs underground, and one of his results, a waggon running round a curve with a rope underneath, was now hanging in the Council chamber. It was not a difficult matter; he preferred magnesium wire to the use of magnesium powder for obtaining a light sufficient for photographing. The best way was to give each assistant—they generally had one or two with them—one or two feet of magnesium wire to light and hold near the object to be photographed. He started to take photographs underground some eight or ten years ago of some fungus in the Cleveland mines; they often had very large fungi, and he thought them so beautiful that they would be interesting as photographs; since then he had taken views of tubs and machinery underground. The magnesium light could not be used in a fiery mine, and, as it made a good deal of smoke there should be a sufficient current of air to carry it away at once.

Mr. W. Lishman (Witton) proposed a vote of thanks to Mr. Steavenson for his entertaining remarks.

Mr. M. Walton Brown seconded the proposal, which was carried with acclamation.

FLAMELESS EXPLOSIVES COMMITTEE.

Mr. W. Lishman (Witton) referred to the appointment of a committee some years ago to report on the use of flameless explosives in mines; he wished to know if any experiments had been made, and, if so, when would the results be communicated to the members of the Institute?

Mr. M. Walton Brown said he was a member of the Flameless Explosives Committee; they had prepared and approved a scheme for the carrying out of the experiments, and obtained estimates for the erection of their apparatus, which would cost about £300. The matter had been laid before the Council, who proposed to ask the Coal Trades Associations for monetary assistance.

The President said it was now only a question of ways and means.

Mr. W. Lishman asked what was the best step to take to raise the money in order that the experiments should be carried out?

The President said he thought the best course was that proposed by the Council, to apply to the coalowners' associations for subscriptions.

Mr. W. Lishman said it was a most pressing matter so far as the trade was concerned.

Mr. Thos. Bell (H.M. Inspector of Mines) said it had been pressing for some time, but it had now become a most important matter.

The PRESIDENT said the Council proposed to bring it before the owners' associations, together with a digest of the principal points of the proposed scheme of experiments, and a request for a contribution to the expense.

Mr. LISHMAN apologised for being so imperative, but he wished to know, if they received an unfavourable answer from the coalowners, were there any other means of getting subscriptions. If the owners refused as an association they would not refuse to subscribe individually.

The PRESIDENT said he thought the coal-owners would be more likely to subscribe as a body than as individuals.

Mr. BLACKETT asked if there were any precedent for an application to Government.

Mr. THOS. BELL said the Government would no doubt think they had already gone to great expense in carrying out the elaborate experiments of the late Royal Commission on Accidents in Mines, and would probably not feel inclined to spend more money at present, and if applied to for a subscription it is possible that the reply would be a refusal, accompanied with a copy of the Report of that Commission.

This concluded the business of the meeting.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, ON SATURDAY, JUNE 14TH, 1890.

MR. GEORGE BAKER FORSTER, PAST-PRESIDENT, IN THE CHAIR.

The CHAIRMAN said he had much pleasure in informing the members that their President, Mr. Marley, was very much better, and hoped soon to be with them again.

The confirmation of the minutes of the previous meeting was postponed.

The SECRETARY said the Council that day had among other things agreed to recommend that the next meeting of the Federated Institution should take place towards the end of July—about the 24th—at Edinburgh. Full details of the proceedings on that occasion would be issued to members in due time, and he would like to notify that if any member had any special paper to send for that meeting it should be sent in early, as it would take some time to get the papers properly ready for the meeting.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. C. H. Eden, Mining Engineer, Old Etherley.

Mr. Leonard Francis Gillett, Mining Engineer, Derby.

Mr. W. H. F. Maddison, Mining Engineer, The Lindens, Darlington.

ASSOCIATE—

Mr. John William Fryar, Mining Student, Seghill Colliery, Seghill, Northumberland.

The following gentlemen were nominated for election :—

MEMBER—

Mr. J. R. M. Robertson, M.D., F.G.S., Mining Engineer, Linton, Mitson's Point, Sydney.

ASSOCIATES—

Mr. Edward Taylor Cheesman, Colliery Manager, Blaydon Main Colliery, Blaydon-on-Tyne.

Mr. Thomas Rontree, Colliery Manager, Harton Colliery, South Shields.

The CHAIRMAN called upon Professor Lebour to read a paper " On Ancient 'Washes' in the Coal-measures."

Professor LEBOUR said he must apologise for appearing as the writer of a paper, but the President, although much better, had not sufficiently recovered from his recent illness as to be able to read his promised paper on " Salt in South Durham ;" he therefore submitted a few observations on the subject of " Ancient 'Washes' in the Coal-measures."*

* This paper will be printed in Vol. II. of the Transactions.

DISCUSSION ON PROFESSOR LEBOUR'S PAPER ON "ANCIENT 'WASHES' IN THE COAL-MEASURES."

Mr. J. B. SIMPSON said he had listened with very much interest to the remarks of Professor Lebour. What he had to say would be very brief, and referred to underground "nips-out," of which he had only had time that morning to make diagrams. In the Five-quarter Seam, at Towneley Colliery, about 300 yards distant from the shaft, they came across a "nip-out" (Fig. 1, Plate I.), and after driving forty yards through it they got into the coal again. There was no fault, they went perfectly straight through, and the workings went 2,000 yards further before another "nip-out" was met with. A section of the first "nip-out" at C D (Fig. 1, Plate I.) is shown in Fig. 2, Plate II. On the east side of the "nip-out," the coal was of the usual thickness, although it tapered sharply as shown on the section (Fig. 2, Plate II.). The seam before coming to this "nip-out," was about 3 feet 4 inches thick, and after passing through 40 yards of sandstone, they found on the west side that sometimes it fortunately increased to 6 feet or 8 feet, and this extended over an area as large as that which had been washed out. In some places there was no thickening of the seam on the western side, but he felt quite sure that if they made an exact calculation they would find they had got as much additional coal on the thicker side as would make up for the loss of coal "nipped out." The same held good with regard to the second "nip-out" (Fig. 2, Plate I.); on the western side they found a thicker seam as shown in the section (Fig. 1, Plate II.) of the drift A B (Fig. 2, Plate I.). Contrary to what the geologists alleged to occur, there was no fault, and the coal was nearly always found without any rise or dip on the other side of the "nip-out." They had pretty much the same thing in other parts of the colliery. The two "nips-out" shown on the diagrams were the largest ones they had; they had not proved how far they extended to the north and south, but he supposed each had been proved about 1,000 yards. The peculiarity was that in the seam 15 fathoms above there were no signs of them, they were purely local to the seam. Of course, the seam resumed its normal thickness when they got a considerable distance away towards the west.

Professor LEBOUR asked whether the coal on the side where it was thickest was of the same quality?

Mr. SIMPSON—Yes; a peculiarity is that there is a band, and on the west side the band is not quite as thick, but more "higgledy-piggledy." The strata here are mostly hard sandstones. We have never found a single boulder.

Mr. W. C. BLACKETT said he would like to ask Mr. Simpson whether he thought it possible that the top part of the thicker seam was upside down? He would also like to ask Professor Lebour whether he thought, from Mr. Simpson's description, that it was a true "nip-out?"

Mr. SIMPSON said he could hardly call it upside down, but it was very much

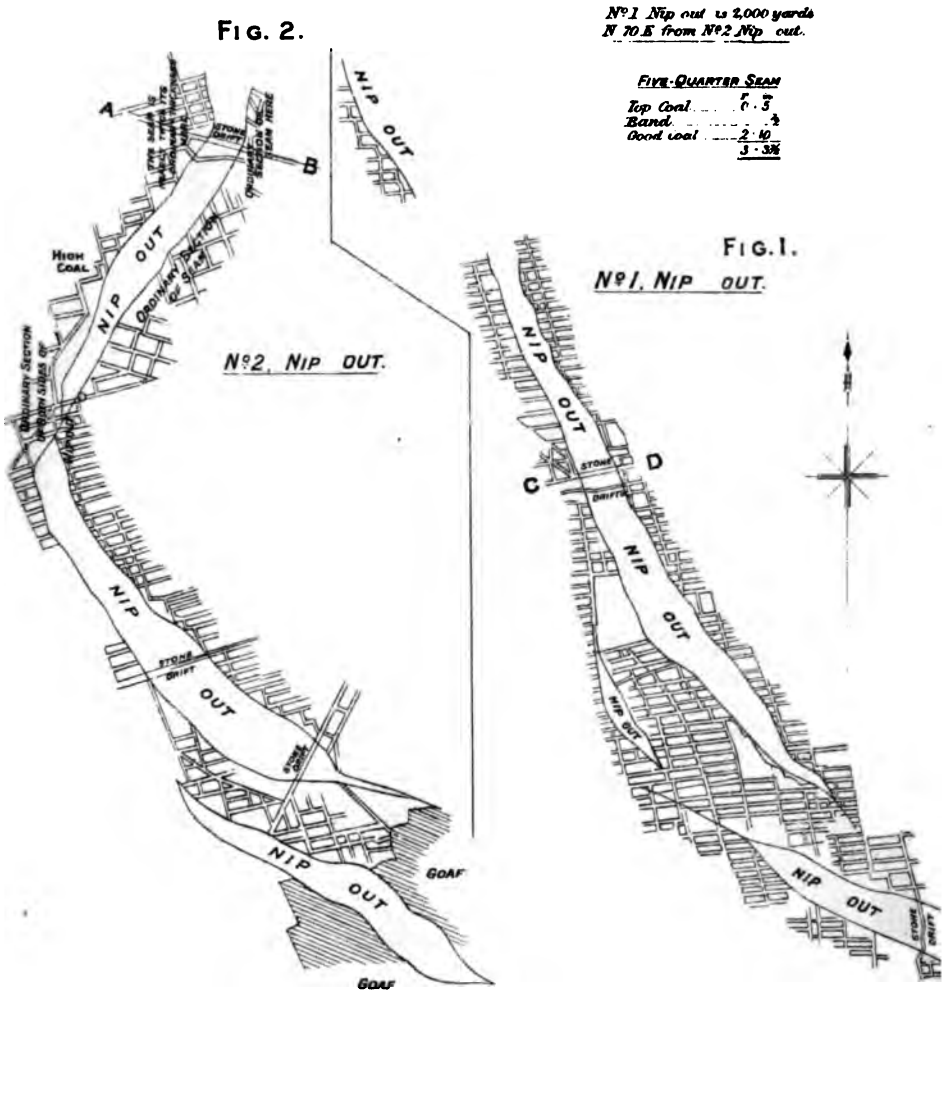
To illustrate Mr. J.B. Simpson's remarks "On Ancient Washes in the Coal Measure.

STELLA AND TOWNELEY COLLIERIES.

EMMA PIT

PLAN SHEWING NIPS OUT IN FIVE-QUARTER SEAM.

Fig. 2.

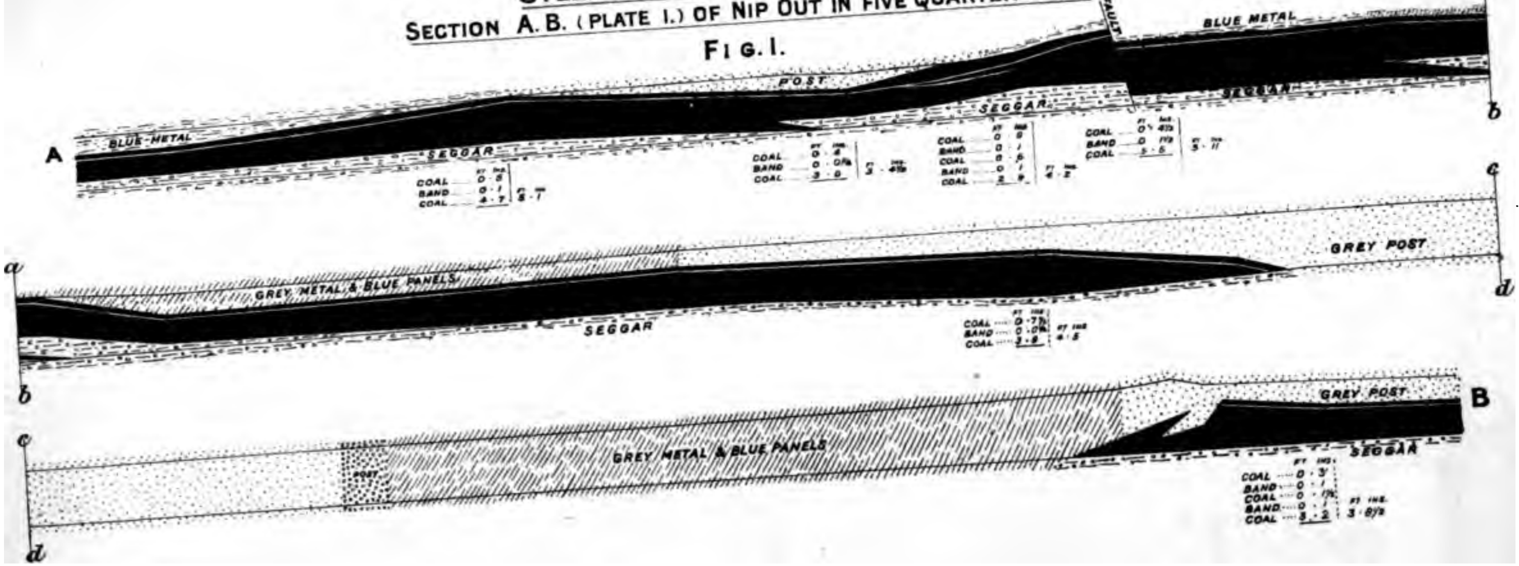


Scale.
10 Chains - 1 Inch.

STELLA & ...

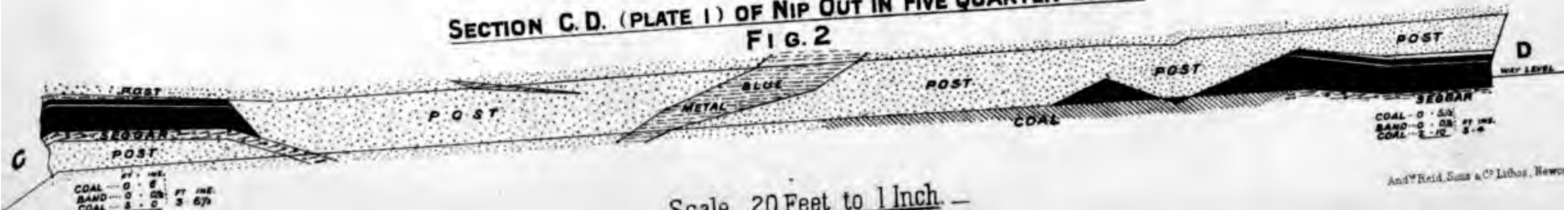
Section A. B. (Plate I.) of Nip Out in Five Quarter Seam.

Fig. I.



Section C. D. (Plate I) of Nip Out in Five Quarter Seam.

Fig. 2



Andw Reid, Sons & Co Lithos, Newcastle.

— Scale, 20 Feet to 1 Inch. —

mixed up. Of course, in a colliery they knew their own seam when they saw it again, but the upper part he could not recognise as the same they had before; the lower part was recognisable, but not the upper part.

Mr. DAGLISH said the terms, "roll," "nip," and "wash-out" had been used somewhat indiscriminately. He ventured to think they were three distinct things. They met with "rolls"—especially with a post-roof—where the roof came down, it might extend a considerable distance, but it was of the same material as the roof, and these "rolls" were local. They met with "nips-out" underground like that described by Mr. Simpson—he (Mr. Daglish) had experienced several in Wales—no change being met with in the overlaying seams, but a great thickening extending over the seam affected in approaching the "nip-out;" there was no deterioration except, perhaps, that the coal was a little softer, but still of excellent quality, and in some cases a 4 feet 6 inch seam became 10 feet and even 12 feet high, and somewhat dangerous to work. In this district, too, they had action of that kind. The Low Main Seam was "nipped-out," not by alluvial deposit but by rock, over a great portion of the Belmont estate, and over the whole of the Grange estate Then, again, they had the "wash-out," such as the Team "wash" or "drift" (described in Messrs. Nicholas Wood and E. F. Boyd's paper, in Volume XIII. of the *Transactions of the North of England Institute*), which passes beside Kimblesworth, and where he (Mr. Daglish) thought there was no alteration of the seams except a little reddening, and they passed from the seams into alluvial matter of a totally different character to the Coal-measures.

Professor LEBOUR said he ventured to think Mr. Daglish was perfectly right in saying the three terms, "roll," "wash," and "nip-out," should be applied to different things. They were three distinct phenomena, and it would be well to describe them by those terms which were now but loosely applied. A "wash"—that is, an ancient "wash"—being often described as a "nip-out," and sometimes by other terms. "Roll" was more generally limited to what it meant—a thinning of the coal—and as Mr. Daglish mentioned, there were a great many of these in the Low Main Seam in certain parts of the Durham coal-field. He would very much like to ask Mr. Daglish if he had any knowledge of the "nip-out" at Whitley?

Mr. DAGLISH said he was not familiar with it, but he did not think if it had been met with underground that the thinning out of the seam would have had anything to do with it. From the diagram, he would say it was a "wedge-out," not a "nip-out." Was the diagram properly drawn?

Professor LEBOUR agreed that it was a case of "wedge-out." He thought it was properly drawn, although there was a great deal of false bedding in the sandstones.

Professor MERIVALE said he was familiar with the "wash-out," or "nip-out," or whatever it might be, in the neighbourhood of Gosforth, and he thought it was drawn correctly, but he could not tell what it was; he had often been puzzled over it. Certainly there was no thickening of the coal as was noticed in so many of the "washes" or "nips-out" in their collieries. He thought one of the largest of these was at Broomhill. About 440 acres, he estimated, of their Main Seam had been swept away, the seams both above and below remaining intact, and the thickening of the coal near the "wash" and in an island of coal in the middle of the "wash" was very marked indeed. It ran 6 or 7 feet of clean coal, without a band in it, in the neighbourhood of the "wash-out," but half a mile away the seam thinned down to 4½ or 5 feet of coal with a band in it. The rock was hard—he understood Mr. Daglish wished to make a distinction between the hard rocks of the "rolls" and the softer rocks in the "wash." Whether that really had anything to do with it or not he did not know, or whether with the hard rock they would expect the seam to be thicker, and with the softer beds they

would not expect it to thicken. He did not quite know whether there should be any connection in this way, but at Broomhill the seam was certainly very much thicker. It seemed possible that they would get a thickening, if the vegetable matter was washed away before it had begun to consolidate, for it would then have had a better chance of being pushed aside and accumulating on either side of the "wash," whereas if it had begun to consolidate it would more probably have been swept away. He did not understand how the smaller "washes"—or whatever they should be called—were formed. One would have supposed the river would have washed a way through a considerable distance instead of picking out a bit here and a bit there.

Mr. J. B. SIMPSON—Would it not rather depend on the level at which the stream was running?

Professor LEBOUR—And the plane along which the river was running may have altered.

Mr. J. B. SIMPSON said there was an interesting "wash" at Prudhoe and Mickley; interesting from a scientific point of view, though not interesting to the coal owners. The Five-quarter Seam was washed out for a width of about 800 yards; and the Six-quarter and Three-quarter Seams were not so much washed out as the upper one. They had just reached the same "wash" in the Brockwell Seam, which was denuded for a breadth of about 40 yards. This large "wash" had been proved, in the Five-quarter Seam, to have a length of about 2¼ miles, and was situated at a considerable height above the sea-level, but joined, he supposed, the great Tyne "wash" and the Team "wash," the latter of which was so ably described by Mr. Wood and Mr. Boyd. No doubt, it was the same "wash," and might be made the subject of a very interesting paper, especially if the observations of Messrs. Boyd and Wood were continued up and down the Tyne.

Professor LEBOUR—I always thought Mr. Simpson was busy on that.

Mr. W. C. BLACKETT said, with regard to the Team "wash," the coal in approaching it did not thicken at all, but simply deteriorated in quality.

The CHAIRMAN—Is it an alluvial "wash?"

Mr. BLACKETT—Yes; and he would like to draw attention to the great difference between the alluvial "washes" and the other "nips-out" mentioned. No deterioration of the coal was found in those described by Mr. Simpson, and that would seem to point to some difference in the ways in which the coal had been denuded, and in the length of time during which the denudation was effected. They had had great difficulty in going over the royalties at Charlaw, Kimblesworth, and Sacriston, where there were some curious "nips-out." In one place the seam went suddenly down in the form of an ordinary "nip," from 3 feet to 10 inches, and continued evenly at this height for a long distance. They had not explored it right through, but it eventually resumed its original height of 3 feet. In another case they had a clean "nip-out," 260 yards wide, and the coal immediately adjoining was as good as anywhere else.

Mr. SIMPSON asked the length of the 260 yards' "nip?"

Mr. BLACKETT said they had not been able to find out. The great difference was—and it was most noticeable—that in the ancient "nip-out" where they usually had a post-roof the coal did not deteriorate in quality even to the very edge, while in the alluvial "washes" the coal was bad for perhaps 100 yards before reaching it. He wished to know whether, in some of the cases of thickened coal approaching a "nip-out," which had been mentioned, it was possible by any means whatever that the seam which had occupied this space could have been turned bodily over?

Professor LEBOUR said he was afraid he could not answer Mr. Blackett's question. It might possibly have drifted over, but then it would be, as Mr. Simpson described it, "higgledy-piggledy," and not turned over bodily.

Mr. T. H. M. STRATTON said that, bearing on the question of "washes-out," they had a series of them at Tredegar which affected every seam in a royalty of over 5,000 acres. These "washes-out," or "barren grounds" as they were there termed, were, as suggested by Professor Merivale, like the bed of a river, but they were not continuous, and in the middle of the "barren ground" little islands of coal were frequently to be found. A "wash-out" or "barren ground" could always be calculated on in a certain general position, but they were not always of the same description; in this one royalty they had all the kinds mentioned to-day. In some cases the coal was good right up to the edge of the "nip-out;" in others it was soft and inferior for a considerable distance. It gave the general impression that a river had removed the coal when in a soft state, and this was confirmed by the fact that frequently the washed out coal was simply deposited on the top of the adjacent seam, thus doubling and sometimes tripling the normal thickness of the seam. The course of the seam could always be traced; the thill or clay was under where the seam once had been. In one case he thus traced a seam for nearly half a mile. It was difficult to explain, and no theory was perfectly satisfactory.

The CHAIRMAN said he had much pleasure in moving a vote of thanks to Professor Lebour for his very interesting notice of these ancient "nips-out," and now that the point had been raised he thought that they should try to elucidate the facts and gather up examples from which alone they could, perhaps, derive a theory. He thought himself there was some difference between alluvial "washes" and what they called "nips-out" underground. In the alluvial "washes" there was no pressure, whereas in the large "nips" found underground there must have been considerable pressure. He had seen some of the Midland "washes" Professor Lebour alluded to, and there was always disturbance of some sort. He recollected one case where the cannel had been carried to another part of the seam, which became a seam with two distinct beds of cannel. With regard to Professor Merivale's suggestion as to the course of the river bed, they did not know whether there may not have been large pools or holes in which the sand was deposited. He had noticed, too, in places along the shore, where the tide sometimes came and sometimes did not, a kind of peaty vegetation grew up, in which there are often hollows. How this was caused he did not know, but it seemed to him that something of this kind might have prevailed and had its effect in regard to the action of the ancient "washes." He hoped they would follow out Professor Lebour's advice and continue this subject, and more especially that Mr. Simpson would proceed with his paper.

The vote of thanks was carried with acclamation.

DISCUSSION ON MESSRS. T. E. FORSTER AND H. AYTON'S PAPER ON "IMPROVED COAL SCREENING AND CLEANING."

The CHAIRMAN announced Messrs. T. E. Forster and H. Ayton's paper "On Improved Coal Screening and Cleaning" open for discussion.

Mr. AYTON said, before entering on the discussion, he would like to mention that one or two alterations had been made in the table of costs since the publication of the paper, as follow:—

On page 94,

TABLE OF COSTS, ETC.

COLUMN.	3.	11.
Total percentage picked out	8·44	19·40
Total load on belts in tons	482	140
Percentage of load picked out... ...	15·06	33·25
	d.	d.
Cost per ton on coal cleaned	1·10	2·28

On page 98, line 5, for "bucket" read "locket."

Professor MERIVALE suggested that some date should be put to the table of costs.

Mr. AYTON said the costs had all been calculated to the same time (October, 1889); in some cases they had found it necessary, from the prices prevailing at different times, to reduce them all to a basis or standard.

Professor MERIVALE said he would like to ask Mr. Ayton if he had had any difficulty with the belt? Theirs had been most successful, and they picked out 25 per cent. more stone, saving about ¼d. per ton, but it made a fearful squeaking.

The CHAIRMAN—It wants a little oil.

Professor MERIVALE—We spend about 15s. a-week on grease, so it is not that.

Mr. AYTON said he had not experienced any difficulty in that matter. Perhaps the rollers were set a little too low.

The CHAIRMAN asked Mr. Steavenson if he had any remarks to make?

Mr. STEAVENSON said he had not. The object in their district was to get the coal small; if they did not get it small enough they smashed it with a breaker.

Mr. J. B. SIMPSON—I think Mr. T. E. Forster might give us his experience on this subject in Australia.

DISCUSSION ON MR. ARNOLD LUPTON'S "NOTES ON THE MEDIUM FAN."

The SECRETARY stated that Mr. Lupton had intended to be present, but he had that morning received a letter from that gentleman stating his inability to be present, and saying that he had sent some diagrams for the meeting. These, however, although it was ascertained that they had arrived in Newcastle, had not yet been delivered, but they were reproduced in the paper, of which copies were on the table, and could therefore be referred to by any gentleman who wished to take part in the discussion. Mr. Lupton was anxious that the discussion should be proceeded with in his absence, and any question which might be asked would be forwarded to him.

Mr. A. L. STEAVENSON said the subject of fans was one which had often been discussed here, and he would not now occupy the attention of the meeting many minutes. The paper seemed to be another instance of the mistakes inventors were apt to fall into. As was pointed out when the paper was first discussed at the Midland Institute, the results said to be attained—107 per cent.—meant more than perpetual motion; it was therefore quite clear that the experiments given were a mistake. He agreed with much of the paper. It was essential that a fan should "produce the required ventilation without breakdowns," "work with the maximum

of economy," and "require the minimum of capital outlay," and under ordinary circumstances he agreed that "the centrifugal machine is first and the rest nowhere." As a general rule they might take it that the centrifugal fan was quite unapproachable for all ordinary work. On the next page, however, it was stated that the Capell fan was "cutting a road to the front." This he entirely disputed. Mr. Capell was, like Mr. Lupton, labouring under a mistake; they made experiments without sufficient care, and showed more air than really existed. He also disputed the statement that "the ordinary method of measuring the velocity for a half minute or one minute is a mere approximation." If the experiments were properly made and the anemometer carefully handled, the results obtained would be accurate. He had proved this over and over again by repeated experiments which gave exactly the same results, provided the conditions were such as permitted accuracy. And with regard to the effects of currents of air on the water-gauge, Professor Herschel had suggested that the mouth of the water-gauge tube should be placed in such a position that the air could not blow into it. With the Schiele and small fans the water-gauge was often very far in excess of what it actually put upon the mine, because they were able to get a vacuum, under which the mine afforded more air than the fan could swallow, and the consequence was that at a certain distance from the fan the water-gauge almost disappeared, while that at the fan was constant. This occurred with all the small fans, but least of all with the Guibal. "A glance will show that there are many inconsistencies, and all that can be said for them is that with such appliances as were at hand, and such time as he could spare for the work, an honest endeavour was made to ascertain the facts." He (Mr. Steavenson) was perfectly ready to accept that. He had not the slightest doubt that Mr. Lupton, Mr. Capell, and other gentlemen who got so far wrong had done it accurately—so far as they knew how. They would no doubt remember that on one occasion a gentleman said he got 70 to 77 per cent., but when Mr. W. Cochrane and himself, with one or two others, went over to the colliery to spend a day over the experiments they obtained very much less. Then as regards the table on page 71. Mr. Lupton gave the water-gauge which he calculated as due to the velocity as 2·14 inches, with 90 revolutions of a 20 feet fan. If they had taken a Guibal fan—where they had the benefit of a chimney—and with the same speed of periphery, the water-gauge due to the speed would have been nearly double what the writer of the paper took it as—viz., $V^2 \div 32$ instead of $V^2 \div 64$. As to the fan described, it seemed to be a sort of cross between the Guibal, Schiele, and Waddle; they were all mixed in it a little; it was a combined fan. In the discussion which followed the reading of the paper there was not much said except that it was quite clear the figures could not be right. He (Mr. Steavenson) quoted one or two extracts from the discussion in question, and, concluding, said he hoped that Mr. Brown, who had had a great deal of trouble in testing various fans, would some day have this one tested, when he was quite sure it would be found to give the usual results of an open running fan, somewhere about 46 to 50 per cent.

The CHAIRMAN—I think it should be pointed out that Mr. Lupton says in a foot-note that this 107 per cent. is evidently a mistake.

Mr. A. L. STEAVENSON—Yes; he admits it is impossible; but my argument is that if one of the experiments is wrong, they all are and must be.

The CHAIRMAN asked Mr. May if he had anything to say on the subject?

Mr. MAY said he had no observations to make, except that with the Guibal fan there was little difference between the water-gauge close to the fan and at the pit bottom.

Mr. M. WALTON BROWN said, if the Guibal fan had been under the same conditions as the Waddle fan it would have shown an equally great resistance and con-

sequent loss of water-gauge at the bottom of the pit. In order to compare the results of Mr. Lupton's experiments on the Medium fan, they should have been made at the same velocity of rotation. The influence of the variations of the velocity could, however, be eliminated by the application of the fundamental principle that in any mine, under the same conditions, the volume of air is proportional to the velocity of rotation, and the water-gauge or depression varies with the square of the velocity of rotation of the fan. The following table shows the results of the experiments when reduced to a normal speed of 4,000 feet of rim, or 63·66 revolutions of fan per minute :—

No. of Experiment.	Water-Gauge.	Volume of Air per Minute.	Efficiency of Fan and Engine.
	Inches.	Cubic Feet.	
1	1·22	65,100	·754
2	1·23	67,200	·782
3	1·07	54,520	·655
4	1·20	56,430	·730

The experiments being made under the same conditions, it is difficult to understand why the volumes and water-gauges observed in the experiments do not accord when reduced to a normal velocity of rotation; and where the manometrical efficiency is as high as ·63 with the volumes of air observed, some doubt attaches naturally as to the accuracy of a mechanical efficiency of ·655, and more especially as to the accuracy of the higher results recorded. It would have added to the value of Mr. Lupton's paper if he had named the colliery where the Medium fan had been applied and could be seen at work. It was a matter of regret that Mr. Lupton was not able to be present at this discussion.

The CHAIRMAN said the Secretary would of course send this discussion to Mr. Lupton, and allow him to make any reply at the next meeting. They could hardly expect him to come to Newcastle, but he would no doubt send some reply on the points raised.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE EXHIBITION LECTURE HALL, EDINBURGH, ON THURSDAY JULY 24TH, 1890.

MR. WILLIAM COCHRANE, VICE-PRESIDENT, IN THE CHAIR.

The CHAIRMAN said he was sorry to have to occupy the chair that day, in consequence of the illness of their President, who still remained too unwell to leave his home. He was sure the members would hear of this with regret, and that they would join in expressing sympathy with Mr. Marley in his indisposition, and in hoping that he would be soon restored to health. The President had been very anxious to be present at this meeting, and quite recently—in fact, only the previous week—told the Secretary he thought he would be strong enough to attend. Unfortunately, however, that hope had not been realised, and they must, therefore, get on as best they could in his absence. The occasion of meeting in Edinburgh was in consequence of the Exhibition. It was, accordingly, felt that but little in the way of outside excursions should be arranged, in order that the members might have an opportunity of examining everything of interest there; the electrical portion was, he believed—though he had not had an opportunity of examining it himself—extremely valuable. Excursions, had been arranged for the following day, under the charge of Mr. Morison, to the Lothian Collieries, which could be reached by going to Dalhousie Station, from which they were distant about a mile, and during the whole of the day any member of the Institution would be welcomed. These collieries were principally interesting in consequence of the very steep seams being worked. On the same day, the manager of the haulage and tram-car arrangements in Edinburgh would be at the central works of the Cable Tramway Company, at Henderson Row, and would be glad to give explanations upon the machinery during the whole of the day. He had only to add that there was a dinner—at which he would like to see as many members as could meet together—arranged for six o'clock that evening, and the Secretary would be glad to take the names of those who would attend. The business for the present meeting was Messrs. Armstrong and Bird's paper on the subject of "The Economical Working of Steam Boilers at Collieries."

Mr. A. L. STEAVENSON then read Messrs. Armstrong and Bird's paper, as follows:—

THE ECONOMICAL WORKING OF STEAM BOILERS AT COLLIERIES.

BY W. ARMSTRONG, JUN., AND W. J. BIRD.

I.—INTRODUCTION.

This elaborate enquiry arose from a desire to test thoroughly the comparative advantages of mechanical stoking and hand-firing, before fitting up a series of the Henderson mechanical furnaces on a range of Lancashire boilers at Wingate Grange Colliery. The results, as will be seen hereafter, were sufficiently satisfactory; and the writers were induced to continue the enquiry into every circumstance affecting the subject, so far as the colliery plant would allow.

Beyond the economic advantages of mechanical over hand-firing—and this more especially applies to boilers of the Lancashire type—the regular and steady supply of fuel, forming a fire of constant thickness, and the automatic cleaning arrangement of the bars, result in an avoidance of those severe and destructive strains throughout the entire structure of the boiler (shortening its life, causing constant leakages and frequent repairs), occasioned whenever the fires require stoking, and more especially cleaning, under the old system.

The experiments have been continued over many months in order to accumulate materials of sufficient interest to lay before the members of this Institution.

All the evaporative tests were made of 48 hours' duration. This is very much longer than tests are usually made, but it was adopted with a view of showing the results obtained under the ordinary working conditions of colliery practice. In the case of the Lancashire boilers, the ordinary working pressure was 35 lbs. from 6 a.m. to 6 p.m., and 60 lbs. from 6 p.m. to 6 a.m., the latter pressure being required during the night for the steam-supply of a large underground pumping engine. In the case of the egg-ended boilers, however, 35 lbs. was the ordinary working pressure day and night.

In all evaporative tests, the condition and size of the fires must, of course, be the same at the end of the test as at the commencement, and this is a matter which personal judgment alone can decide. Any error in such an estimate may be a materially disturbing factor in tests of short duration, but over a long period of 48 hours the proportions of any possible mistaken comparison of the fires become infinitesimal.

When the Admiralty experiments were made at Newcastle to determine the evaporative efficiency of Northumberland coal, the test period was fixed at 5 hours only, and the experiments may, therefore, show erroneous results.

The amount of coals burnt, and the resultant ash was ascertained by careful weighing.

A Siemens' water-meter was fixed on the feed-water pipe to record the amount of water evaporated. Its accuracy was tested at intervals during the period over which the experiments extended, by comparison with a tank of known capacity. The instrument was specially adapted for hot water, and registered up to 1,000,000 gallons, and care was taken that the water-level in the boiler was the same at the end of each test as at the commencement.

The weight of water evaporated is frequently computed by estimating 10 lbs. = 1 gallon, irrespective of the temperature of the feed. How serious an error this may occasion will be seen from Table I., which shows the true proportions at different temperatures, and by which all results of these experiments were computed.

The feed water for the Lancashire boilers is heated in a Twibell's Economizer, placed at the end of the main flue; and that for the egg-ended boilers by the exhaust steam from the engines. The temperatures were taken by thermometers screwed into the feed pipe.

The apparent duty is calculated by dividing the weight of water evaporated by the weight of fuel burnt. Then the variations in the temperatures of the

TABLE I.

Weight of a Gallon of Water at various Temperatures.

Temp.	Pounds.	Temp.	Pounds.	Temp.	Pounds.	Temp.	Pounds.
°		°		°		°	
32	10·0137	107	9·9254	151	9·8097	195	9·6624
34	10·0140	108	9·9233	152	9·8067	196	9·6587
36	10·0144	109	9·9212	153	9·8036	197	9·6550
38	10·0147	110	9·9191	154	9·8005	198	9·6513
40	10·0150	111	9·9170	155	9·7974	199	9·6476
42	10·0147	112	9·9149	156	9·7943	200	9·6439
44	10·0138	113	9·9124	157	9·7912	201	9·6402
46	10·0129	114	9·9099	158	9·7881	202	9·6364
48	10·0120	115	9·9074	159	9·7850	203	9·6327
50	10·0110	116	9·9059	160	9·7819	204	9·6290
52	10·0100	117	9·9024	161	9·7788	205	9·6253
54	10·0080	118	9·8999	162	9·7756	206	9·6216
56	10·0060	119	9·8974	163	9·7724	207	9·6179
58	10·0040	120	9·8949	164	9·7692	208	9·6142
60	10·0020	121	9·8924	165	9·7660	209	9·6105
62	10·0000	122	9·8898	166	9·7628	210	9·6068
64	9·9978	123	9·8873	167	9·7596	211	9·6031
66	9·9956	124	9·8848	168	9·7564	212	9·5994
68	9·9934	125	9·8823	169	9·7532	214	9·5914
70	9·9912	126	9·8798	170	9·7500	216	9·5834
72	9·9889	127	9·8773	171	9·7468	218	9·5754
74	9·9859	128	9·8748	172	9·7436	220	9·5674
76	9·9829	129	9·8723	173	9·7402	222	9·5594
78	9·9799	130	9·8698	174	9·7368	224	9·5514
80	9·9769	131	9·8673	175	9·7334	226	9·5434
82	9·9739	132	9·8648	176	9·7300	228	9·5354
84	9·9703	133	9·8620	177	9·7266	230	9·5273
86	9·9667	134	9·8592	178	9·7232	232	9·5190
88	9·9631	135	9·8564	179	9·7198	234	9·5107
90	9·9595	136	9·8536	180	9·7164	236	9·5024
92	9·9559	137	9·8508	181	9·7130	238	9·4941
94	9·9519	138	9·8480	182	9·7095	240	9·4858
95	9·9499	139	9·8452	183	9·7059	242	9·4775
96	9·9479	140	9·8424	184	9·7023	244	9·4692
97	9·9459	141	9·8396	185	9·6987	246	9·4609
98	9·9439	142	9·8367	186	9·6951	248	9·4525
99	9·9419	143	9·8337	187	9·6915	250	9·4441
100	9·9399	144	9·8307	188	9·6879	252	9·4354
101	9·9379	145	9·8277	189	9·6843	254	9·4267
102	9·9359	146	9·8247	190	9·6807	256	9·4180
103	9·9338	147	9·8217	191	9·6771	258	9·4093
104	9·9317	148	9·8187	192	9·6735	260	9·4006
105	9·9296	149	9·8157	193	9·6698	262	9·3919
106	9·9275	150	9·8127	194	9·6661	264	9·3832

feed-water and of evaporation require correction to one common standard to ascertain the real comparative duty. The standard adopted was 212 degs. Fahr. temperature of feed-water, and 212 degs. Fahr. temperature of evaporation, the corrections being made by the following formula :—

$$C = \frac{A\,[\,1{,}081{\cdot}4 + ({\cdot}305 + t)\,] - (t - 32)}{L}.$$

In which C = Corrected duty,
A = Apparent duty,
t = Temperature of evaporation in degs. Fahr. deduced from the average steam pressure, and
L = Latent heat of steam at 212 degs. Fahr. = 966 units.

The corrected duty is used as the proper standard of comparison.

The rate of fuel combustion is shown per square foot of fire-grate surface per hour.

The cost of evaporation of 1,000 gallons of water is also shown. The standard temperature of the water is taken at 62 degrees Fahr., and the quantities are corrected accordingly. The relative positions of the boilers are shown in Fig. 1, Plate I.

II.—Experiments upon a Lancashire Boiler, Hand-Fired, and Fitted with the Henderson Mechanical Stoker.

The first series of tests were made on a Lancashire boiler 28 feet long by 7 feet 6 inches diameter. Three 48 hour tests were made by hand-firing with rough small coal, and two with duff coal. The boiler was then fitted up with the Henderson Patent Mechanical Stoker and Self-Cleaning Bars, and a corresponding number of tests made with this apparatus, the construction of which is set forth as follows, and illustrated in Plate II.:—

I.—Description of the Henderson Mechanical Stoker.

The coals are thrown on to the fire by means of horizontal circular fans revolving in opposite directions towards the furnace. The fans are set in motion by frictional pulleys attached to the driving shaft running under the fan boxes, at the end of which is the belt-pulley. At the central driving shaft is a wheel, working into a worm-wheel B, attached to a vertical shaft on the top of which is another worm A, which drives the crushers above the fans. In front of these crushers there is a plate worked by a hand-screw from the outside for regulating the feed of fuel, and against which any large pieces of coal are broken to the proper size before going on to the fire. At the bottom of the vertical shaft is another worm C, and wheel for working the furnace bars, which rest on a rocker or cradle of very simple construction, by which means half the bars are moved up and down vertically, thus breaking up the clinker and keeping the fire open, while the other half of the bars travel backwards and forwards horizontally, taking with them the clinker and refuse from the coal to the back of the furnace, where they are deposited over the back-end of the fire-bars into the combustion chamber, and form a natural bridge. The clinker and refuse are taken out of this chamber, when cold, by opening a damper door at the back-end under the bars. The bars in each furnace can be thrown out of gear at will by means of a thumbscrew attached to the crank in front. By means of a clutch the bars can be disconnected entirely from the machine, and the bars only left working. The fire-doors are so constructed that hand-firing can be carried on when necessary, which is very useful in the case of anything going wrong with the machinery; the fires are then still self-cleaned, while the boiler need not be laid off, nor the boiler power at all interfered with.

II—Increased Duty and Saving of Fuel.

On comparing the results of mechanical stoking with those of hand-firing when using the same kind of fuel, there is an increase of duty of 33·3 per cent., with a diminution of cost of evaporation of 23 per cent. when small coal was used. When duff coal was used the duty was increased 35·9 per cent. by mechanical stoking, while the cost of evaporation was diminished 24·5 per cent.

Again, comparing hand-firing with small coal with mechanical stoking with duff coal, the duty is increased 23·2 per cent., and the cost of evaporation is diminished 52·4 per cent.; the cost of fuel being 1s. 6d. per ton less.

TABLE II.

Lancashire Boiler.		Rough Small Coal. Hand-firing. No. 1. Nov. 2-4.	No. 2. Nov. 9-11.	No. 3. Nov. 16-18.	Average.	Henderson Mechanical Stoker. No. 1. Jan. 25-27.	No. 2. Feb. 1-3.	No. 3. Feb. 21-23.	Average.	Advantage of Stoker. Proportion per Cent. Increase.	Decrease.
Coal burnt	lbs.	21,735	23,513	22,498	22,582	22,127	23,247	24,416	23,263	3·0	...
Water evaporated	gals.	14,280	15,534	14,386	14,733	18,193	19,330	20,880	19,468	32·1	...
Do. per hour	gals.	297	324	299	307	379	403	435	405	32·1	...
Temp. of feed-water (average)	degs. F	165	165	165	165	132	132	140	134	...	...
Water evaporated	lbs.	139,458	151,705	140,493	143,882	179,470	190,687	205,509	191,939	33·4	...
Apparent duty	lbs.	6·42	6·45	6·24	6·37	8·11	8·20	8·42	8·25	29·5	...
Corrected duty	lbs.	6·89	6·93	6·71	6·85	8·99	9·10	9·26	9·13	33·3	...
Coal burnt per square foot of grate surface per hour	lbs.	12·82	13·74	13·15	13·24	18·25	19·18	20·15	19·19	45·0	...
Proportion of ashes	%	13·1	12·6	15·5	13·7	6·5	8·9	10·6	8·7	...	36·5
Value of fuel per ton	s. d.	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	...	..
Cost of evaporating 1,000 gallons of water at 62 degs. Fahr.	s. d.	2/5·4	2/5·2	2/6·2	2/5·6	1/11·2	1/11·0	1/10·4	1/10·8	...	23·0

TABLE II.—CONTINUED.

Lancashire Boiler.		Duff Coal. Hand-firing. No. 1. Nov. 23-25.	Duff Coal. Hand-firing. No. 2. Nov. 29. Dec. 1.	Duff Coal. Hand-firing. Average.	Duff Coal. Henderson Mechanical Stoker. No. 1. Feb. 29. March 2.	Duff Coal. Henderson Mechanical Stoker. No. 2. Mar. 27-29.	Duff Coal. Henderson Mechanical Stoker. Average.	Duff Coal. Advantage of Stoker. Proportion per Cent. In-crease.	Duff Coal. Advantage of Stoker. Proportion per Cent. De-crease.	Hand-firing with Rough Small Coal. Average.	Mechanical Stoker with Duff Coal. Average.	Comparative Advantage of Stoker. Proportion per Cent. In-crease.	Comparative Advantage of Stoker. Proportion per Cent. De-crease.
Coal burnt	lbs.	24,136	21,280	22,708	27,440	27,496	27,468	21·0	...	22,582	27,468	21·6	...
Water evaporated	gals.	13,040	13,279	13,160	20,922	20,915	20,919	59·0	...	14,733	20,919	42·0	...
Do. per hour	gals.	272	276	274	436	436	436	59·0	...	307	436	...	...
Temp. of feed-water (aver.)	degs. F	149	149	149	118	124	121	...	...	165	121	...	...
Water evaporated... ...	lbs.	127,997	130,343	129,175	207,126	206,741	206,939	60·2	...	143,882	206,939	43·8	...
Apparent duty	lbs.	5·31	6·13	5·69	7·55	7·52	7·53	32·3	...	6·37	7·53	18·2	...
Corrected duty	lbs.	5·79	6·68	6·21	8·48	8·40	8·44	35·9	...	6·85	8·44	23·2	...
Coal burnt per square foot of grate surface per hour	lbs.	14·11	12·44	13·28	22·64	22·69	22·67	70·7	...	13·24	22·67	71·2	...
Proportion of ashes ...	%	15·3	16·7	16·0	10·1	11·7	10·9	...	31·9	13·7	10·9	...	20·4
Value of fuel per ton ...	s. d.	2/-	2/-	2/-	2/-	2/-	2/-	..	...	3/6	2/-	...	42·9
Cost of evaporating 1,000 gallons of water at 62 degs. Fahr.	s. d.	1/8·2	1/5·5	1/6·8	1/2·2	1/2·3	1/2·2	...	24·5	2/5·6	1/2·2	...	52·4

(Fire-grate areas were :—with hand-firing, 35·64 square feet; with Henderson Mechanical Stoker, 25·25 square feet.)

The cost of fuel per boiler per annum, based on these results, can now be calculated. The year may be assumed at 300 working days, which is a pretty close approximation to actual practice; and the average evaporation under mechanical firing is taken as the basis :—

Fuel.	Annual cost of Fuel per Boiler. Hand-firing.	Annual cost of Fuel per Boiler. Mechanical Stoker.	Saving.
	£ s. d.	£ s. d.	£ s. d.
Small at 3s. 6d. per ton ...	360 3 2	277 8 5	82 14 9
Duff at 2s. 0d. per ton ...	245 16 0	185 13 1	60 2 11

The annual saving of fuel per boiler, when small coal is used, is thus £82 14s. 9d., or about 90 per cent. per annum on the cost of the apparatus. If, however, hand-firing with small coal is compared with mechanical firing with duff coal, the saving is much greater, and amounts to £174 10s. 1d. per annum.

III.—Experiment with the Henderson Fire-bars, Hand-fired.

To determine in what degree each part of the mechanical stoker contributed to the remarkable increase of duty, a test was made on the Lancashire boiler with the Henderson movable bars only, the coal being stoked by hand. The results were as follow :—

Coal burnt (in 48 hours)	23,772 lbs.
Water evaporated	17,873 gallons.
Do. per hour	370 gallons.
Temperature of feed-water	132 degs. Fahr.
Water evaporated	176,313 lbs.
Apparent duty	7·42 lbs.
Corrected duty	8·22 lbs.
Do.	20 % increase.
Coal burnt per square foot of grate surface, per hour.	19·61 lbs.
Proportion of ashes	8·1 per cent.
Value of fuel	3s. 6d. per ton.
Cost of evaporating 1,000 gallons of water at 62 degs. Fahr.	2s. 1·4d.

It thus appears that the increase of duty due to the bars is 20 per cent. out of the 33·3 per cent. increase yielded by the whole apparatus. Accounting out of this 20 per cent. for the proportion gained by the diminution of ashes, the useful effect of the Henderson mechanical stoker and bars may be thus analysed :—

	Per Cent.
Diminution of ashes increases duty	6·0
Movable furnace bars	14·0
Effect of mechanical stoking	13·3
Total effect of the whole apparatus	33·3

III.—Experiments upon Egg-ended Boilers, Covered and Uncovered, with two Arrangements of Bridges and Flues, and fitted with the Juckes Fire.

The next series of evaporative tests were made in a range of egg-ended boilers, worked with the Juckes Fire. The tests were made upon two of the boilers, viz., No. 5, 38 feet long by 6 feet diameter, and No. 6, 28 feet long by 6 feet diameter. In No. 5 boiler the tests were made with the boiler covered and uncovered, and with a new arrangement of bridges and flues. In the No. 6 boiler the tests were made with the boiler covered.

TABLE III.

No. 5 and No. 6 Egg-ended Boilers, with the Juckes Fires.		No. 5 Boiler, 38 feet by 6 feet.										No. 6 Boiler, 28 feet by 6 feet.			
		Old Arrangement of Bridge and Flues.								New Bridges and Flues.		Old Bridge and Flues.			
		Boiler Uncovered.				Boiler Covered.				Uncv'd.	Covered.	Boiler Covered.			
		No. 1.	No. 2.	No. 3.	Average.	No. 1.	No. 2.	No. 3.	Average.	No. 1.	No. 1.	No. 1.	No. 2.	No. 3.	Average.
Coal burnt	lbs.	14,896	13,868	14,112	14,292	22,550	21,693	19,812	21,353	20,859	20,076	18,137	18,529	17,698	18,121
Water evaporated	gals.	5,675	6,795	7,745	6,738	11,214	10,830	9,560	10,535	10,155	10,007	9,816	8,575	8,032	8,808
Do. per hour ...	gals.	118	141	161	140	234	226	199	219	212	208	204½	179	167	183½
Temp. of feed-water (average)	degs. Fahr.	210	210	210	210	210	210	210	210	210	210	210	190	210	203
Water evaporated	lbs.	54,519	65,278	74,405	64,731	107,731	104,042	91,841	101,208	97,082	96,135	94,300	83,012	77,162	84,845
Apparent duty	lbs.	3·66	4·71	5·27	4·53	4·78	4·79	4·64	4·74	4·65	4·79	5·20	4·48	4·36	4·68
Corrected duty	lbs.	3·75	4·82	5·40	4·64	4·89	4·91	4·74	4·85	4·77	4·90	5·32	4·68	4·46	4·82
Coal burnt per square foot of grate surface per hour ...	lbs.	7·52	7·00	7·13	7·22	11·39	10·96	10·01	10·78	10·53	10·14	9·16	9·36	8·94	9·15
Proportion of ashes	%	40·9	37·6	40·5	39·7	...	...	31·3	31·3	45·1	41·7	34·0	32·6	29·8	32·1
Value of fuel per ton ...	s. d.	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6	3/6
Cost of evaporating 1,000 gallons of water at 62° Fahr.	s. d.	4/3·5	3/4·0	2/11·7	3/5·6	3/3·4	3/3·2	3/4·6	3/3·7	3/4·5	3/3·3	3/0·0	3/6·0	3/7·2	3/4·2

As before stated, the working steam pressure was 35 lbs. per square inch, day and night. In every case but one the feed-water was maintained at a constant temperature of 210 degs. Fahr. by the use of the exhaust steam.

The proportion of ashes obtained in these tests was extraordinarily large, and the circumstance of so much of the fuel being unburnt accounts for the comparatively low rate of duty.

Table III. contains the whole of the tests made with the Juckes Fires on No. 5 and No. 6 boilers, with the results calculated from them.

Thus, the corrected duty is 4·85 lbs. for the long boiler, and 4·82 lbs. for the short boiler, a quite insignificant difference, the variation in the proportion of ashes being very small; and it would appear that within certain limits the comparative length of a cylindrical boiler has no influence on its duty.

I.—Results of Old and New Arrangements of Bridges and Flues.

The No. 5 boiler was tested first with the old arrangement of bridges and flues, and then with a new adaptation. These two arrangements are shown in Figs. 1, 2, 3, 4, 5, and 6, Plate III.

The effect of the new adaptation on the effective duty is easily shown. With the boiler uncovered, the respective corrected duties are—old plan, 4·64 lbs.; new plan, 4·77 lbs.; with the covered boiler, 4·85 lbs. and 4·90 lbs. respectively. At first sight the difference would seem to be insignificant. But when we take into account the differences in the respective proportions of ashes, and eliminate these factors, the theoretical duties will stand as follows:—Boiler uncovered, old plan, 7·69; new plan, 8·62; increase, 12·6 per cent. Boiler covered, old plan, 7·06; new plan, 8·40. Increase, 19·0 per cent.

The mean of these increments may, therefore, be taken as a fair representation of the improved useful effect by the adoption of the new flues and bridges, and the gain per cent. may be estimated at [(12·6 + 19·0) ÷ 2 =] 15·8 per cent.

There is frequent occasion to take into account differences in the proportion of ashes, and to eliminate that varying factor in order to arrive at any trustworthy comparison.

In these cases a theoretical or adjusted duty is deduced from the corrected duty as follows:—

$$D^1 = \text{Adjusted or theoretical duty} = \frac{D}{100-p}.$$

In which D = Corrected duty, and p = Percentage of ashes.

II.—Results of Covered and Uncovered Boiler.

Table IV. contains the comparative results of a series of tests on No. 5 boiler, covered and uncovered.

The boiler was, of course, only covered on the portion exposed above the masonry, not much more than one-third of the total surface. The gain from the use of this non-conducting covering is represented by an increase of 4·1 per cent. of the corrected duty. When, however, the proportion of ashes is taken into account, and the adjusted duties compared, the 4·1 per cent. completely disappears, and is replaced by a decrease of 7·3 per cent., a result which is absurd.

This discordance may be accounted for by the fact that in the first two tests made on No. 5 boiler the quantity of ashes had not been observed, and the quantity in No. 3 test (31·3 per cent.) is assumed as the average of Nos. 1, 2, and 3, which assumption is very probably erroneous.

An endeavour must, therefore, be made to find some means of checking the accuracy of the comparisons, and fortunately such a method is available.

TABLE IV.

No. 5 Egg-Ended Boiler.		Boiler Uncovered. Old Bridges and Flues. Average of Three Tests.	Boiler Uncovered. New Bridges and Flues. One Test, Oct. 1-3.	Boiler Uncovered. Average of Four Tests.	Boiler Covered. Old Bridges and Flues. Average of Three Tests.	Boiler Covered. New Bridges and Flues. One Test, Nov. 7-9.	Boiler Covered. Average of Four Tests.	Comparison of Results. Increase. Per Cent.	Comparison of Results. Decrease. Per Cent.	Comparison by Dulong's Formulæ. Increase. Per Cent.	Comparison by Dulong's Formulæ. Decrease. Per Cent.
Coal burnt	lbs.	14,292	20,859	15,934	21,353	20,076	21,034	...	...	...	...
Water evaporated	gals.	6,738	10,155	7,587	10,535	10,007	10,403	...	...	...	...
Do. per hour	gals.	140	212	158	219	208	217	...	...	...	...
Temp. of feed-water (average)	degs. F.	210	210	210	210	210	210	...	...	...	...
Water evaporated	lbs.	64,731	97,082	75,319	101,208	96,135	99,937	...	...	...	...
Apparent duty...	lbs.	4·53	4·65	4·56	4·74	4·79	4·75	4·2	...	...	...
Corrected duty...	lbs.	4·64	4·77	4·67	4·85	4·90	4·86	4·1	...	3·7	..
Coal burnt per square foot of grate surface per hour	lbs.	7·22	10·53	8·05	10·78	10·14	10·62	...	...	...	...
Proportion of ashes	%	39·7	45·1	41·0	31·3	41·7	33·7	...	...	...	...
Value of fuel per ton...	s. d.	3/6	3/6	3/6	3/6	3/6	3/6	...	...	...	...
Cost of evaporating 1,000 gallons of water at 62° F.	s. d.	3/5·6	3/4·5	3/5·3	3/3·7	3/3·3	3/3·6	...	4·1	...	...
Theoretical duty (ashes eliminated)	lbs.	7·69	8·62	7·92	7·06	8·40	7·34	...	7·3	..	...

The researches of Dulong enable one to find the amount of heat given off from a surface at a higher temperature than the surrounding medium, when their respective temperatures are known. This is divided into heat lost by radiation and heat lost by contact of air.

For small differences of temperature between the radiating substance and the absorbent medium, the loss of heat by radiation is simply proportional to the difference in temperature, but at higher temperatures and for greater differences the loss of heat is much greater, following a complicated law represented by Dulong's equation :—

$$r = \frac{124{\cdot}72 \times 1{\cdot}0077\, t \times (1{\cdot}0077^{T} - 1)}{T}$$

when t = temperature (centigrade degrees) of absorbent,

T = excess temperature of radiating body (centigrade degrees),

r = ratio of loss of heat under the given temperatures.

The loss of heat by radiation is also dependent on the nature of the radiating substance, different surfaces giving very different results. These have been determined by experiment for a great number of substances. R is the number of units of heat emitted per square foot per hour, for a difference in temperature of 1 deg. Fahr. The total loss of heat by radiation is, therefore, $R \times D \times r$, when D = difference in temperatures of radiant and absorbent.

The loss of heat by contact of air is independent of the nature of the substance, but the form of the body affects the result considerably. In the case of a horizontal cylinder, if A = loss in units per square foot of surface per hour, for a difference of 1 deg. Fahr., and r = radius of the cylinder in inches,

$$A = {\cdot}421 + ({\cdot}307 \div r).$$

The heat lost by air-contact increases more rapidly than the simple ratio of excess of temperature, and is found by the formula :—

$$r^1 = \frac{{\cdot}552 \times t^{1{\cdot}233}}{t},$$

when t = difference of temperatures (centigrade degrees), and r^1 = ratio of loss of heat with that difference.

The total loss of heat by air-contact is thus = $A \times D \times r^1$, when D = difference of temperatures between substance and air.

III.—Temperatures of Boiler and Covering.

The first series of temperature observations were taken to check the six tests (uncovered and covered) of No. 5 boiler with the old bridges and flues, and averaged as follows :—

	Degs. Fahr.
Temperature—Uncovered boiler surface	275
,, Covered boiler surface	106
Temperature of air	73

Using the above formula the total loss of heat per square foot per hour is—

	Units.
Uncovered boiler	414·00
Covered boiler	45·18

and multiplying by the respective superficies the total loss per hour is—

	Units.
Uncovered boiler	110,289·60
Covered boiler	13,192·56
Difference =	97,097·04.

For the whole 48 hours the heat loss would be—

$$97{,}097 \times 48 = 4{,}660{,}658{\cdot}88 \text{ units.}$$

With a feed-water temperature of 210 degs. and steam pressure of 35 lbs., the total heat of the steam (from 210 degs.) = 988·7 degs. Fahr., and 4,660,658·88 ÷ 988·7 = 4,715 lbs. of water evaporated, equivalent to loss of heat for 48 hours.

The water evaporated per 48 hours on the average of the three earlier tests in the uncovered boilers, was	= 64,731 lbs.
Add loss	= 4,715 „
Then average water evaporation in covered boiler	= 69,446 „

Coal consumption = 14,292 lbs., and 69,446 ÷ 14,292 = 4·86 lbs. deduced corrected duty for covered boiler, compared with 4·85 lbs. corrected duty for covered boiler observed, or 4·7 per cent. increase over corrected duty of uncovered boiler.

The next series of temperature observations were made to check the two tests (uncovered and covered) made on October 1st and November 7th, 1888.

The average temperatures observed were :—

	Degs. Fahr.
Uncovered boiler—Temperature of surface... ...	280
„ Temperature of air	54
Covered boiler—Temperature of surface	91
„ Temperature of air...	48

Working from these figures as previously, the corrected duty in the uncovered boiler of 4·77 lbs. is increased to 4·90 lbs. in the covered boiler, or 2·7 per cent. increase.

Referring to Table IV., the observed corrected duty shows an increase of 4·1 per cent. when the boiler is covered; and checking the comparison by Dulong's method, the increase of duty is found to be 4·7 per cent. increase from one set of observations, compared with 2·7 per cent. with a second series; making an average of 3·7 per cent. increase, which corresponds very nearly with the 4·1 per cent. increase observed.

This is, therefore, a satisfactory confirmation of the accuracy of the comparative tests, so far as the corrected duty is concerned, and, doubtless, had the proportion of ashes been observed in the first two tests, the comparison would have remained unaffected as regards the theoretical duties.

IV.—Further Experiments upon an Egg-ended Boiler, with New Arrangement of Bridges and Flues, and Hand-Fired. (Plate III.)

Another series of tests was made with an egg-ended boiler 41 feet long by 6 feet diameter, with hand-firing, which had just been fitted with the new arrangement of bridges and flues. The results obtained (see Table V.) were remarkably good, the corrected duty on the average of three tests being 6·07 lbs. It will be noted that the proportion of ashes is much less than in the case of the Juckes Patent Fires, namely, 17 per cent. as compared with over 30 per cent.

Comparing the respective averages of three tests with long boilers by hand-firing and the Juckes Fires, the corrected duties for the Juckes Patent Fires is 4·85 lbs., with 31·3 per cent. of ash, and for hand-firing 6·07 lbs., with 17·0 per cent. of ash.

Calculating the respective theoretical duties they come out: Juckes Patent Fires, 7·06 lbs.; hand-firing, 7·31 lbs.; and thus the patent fires seem to show positively worse results than hand-firing. It must be remembered, however, that the hand-firing tests were made with the new arrangement of bridges and flues which, as shown previously, are equal to a gain of 15·8 per cent. Deducting this proportion from the hand-firing figures, the comparative theoretical duties with old flues and

TABLE V.

Egg-ended Boiler (Beeswing) 41 feet long by 6 feet diameter, and Hand-Fired.		New Arrangement of Bridges and Flues.			
		No. 1. July 26-28.	No. 2. July 31-Aug. 2.	No. 3. Aug. 6-8.	Average.
Coal burnt	lbs.	22,148	21,280	21,700	21,709
Water evaporated ...	gals.	13,913	12,924	13,345	13,394
Do. per hour.	gals.	290	269	278	279
Temp. of feed-water (av.)	degs. F	210	210	210	210
Water evaporated ...	lbs.	133,659	124,158	128,203	128,673
Apparent duty	lbs.	6·03	5·83	5·91	5·93
Corrected duty	lbs.	6·18	5·97	6·05	6·07
Coal burnt per sq. foot of grate surface per hour ..	lbs.	17·09	16·42	16·74	16·75
Proportion of ashes ...	%	17·0	15·5	18·6	17·0
Value of fuel per ton ...	s. d.	3/6	3/6	3/6	3/6
Cost of evaporating 1,000 gallons of water at 62° F.	s. d.	2/7·2	2/8·3	2/7·9	2/7·8

bridges are: Juckes Fires, 7·06 lbs.; hand-firing, 6·31; an apparent advantage of 11·9 per cent. in favour of the Juckes Fires.

It may, therefore, be concluded that the use of the Juckes Fires affords a theoretical increase of duty of about 12 per cent., which in practice is *more than counterbalanced* by the increase in the proportion of unburnt fuel.

V.—Experiments upon a Lancashire Boiler, as to the Effect of Boiler Scale upon the Duty.

The next series of observations made referred to the effect of scale in a boiler in diminishing the duty of the fuel.

No. 21 Lancashire boiler was selected for making the comparison. Like the others in the range it was 28 feet long by 7 feet 6 inches diameter. The inside was cleaned as perfectly as possible before the first 48 hours' test was made, after which the boiler was under steam about seven weeks. By this time a scale of $\frac{1}{16}$ inch in thickness had accumulated in the boiler, and the second 48 hours' test was made. Table VI. shows the comparative results of the two tests.

TABLE VI.

No. 21 Lancashire Boiler.		Clean Boiler. April 2-4, 1889.	Dirty Boiler. May 21-23, 1889.	Comparison. + %	Comparison. −%
Coal burnt	lbs.	25,984	22,848	...	12·1
Water evaporated	gals.	18,850	15,100	...	19·9
Do. per hour	gals.	393	315	...	19·9
Temp. of feed-water (average).. ...	degs. F	121	115	...	...
Water evaporated	lbs.	186,472	149,602	...	19·8
Apparent duty	lbs.	7·18	6·54	...	8·9
Corrected duty	lbs.	8·04	7·36	...	8·5
Theoretical or adjusted duty	lbs.	9·23	9·09	...	1·5
Coal burnt per square foot of fire grate surface per hour	lbs.	21·44	18·85	...	12·1
Proportion of ashes	%	12·9	19·1	...	...
Value of fuel per ton	s. d.	3/6	3/6	...	...
Cost of evaporating 1,000 gallons of water, at 62 degs. Fahr.	s. d.	2/2·1	2/4·6	9·6	...

This comparison has been complicated by the variation in the amount of ashes.

The dirty boiler shows a falling off in corrected duty of 8·5 per cent., but when the respective proportions of ash are taken into account the difference is reduced to 1·5 per cent., *which is all that can be attributed to the action of one-sixteenth of an inch of boiler scale.*

VI.—Experiments upon a Lancashire Boiler, with Ordinary and Checker Fire-Brick Bridges.

A further series of tests were made on No. 23 Lancashire boiler to determine the effect of checker fire-brick work in the place of bridges. Two experimental arrangements of brickwork were made as shown in Figs. 2 and 3, Plate I.

A 48 hours' test with hand-firing, and the ordinary bridge was made on the No. 23 boiler, beginning May 1st, 1889, after which the arrangements in Figs. 2 and 3 were successively tested with the results contained in Table VII.

The fixing of the No. 1 bridge, Fig. 2, diminished the evaporation by 60 gallons an hour, but the saving in fuel was more than proportionate. The adjusted duties are 9·35 lbs. with the ordinary bridge, or 9·82 lbs. with the No. 1 new bridge, an increase of 5 per cent. At the same time, desirable as the 5 per cent. increase in duty might be, an accompanying disadvantage was the fall in evaporative power of the boiler from 347 gallons per hour to 287 gallons per hour, a loss of 17·3 per cent.

The arrangement in Fig. 3 was then designed with the object of securing the 5 per cent. increase of duty, while avoiding any marked loss in evaporative power. The comparison of the tests then made shows that the theoretical duties are 9·35 lbs. in the old bridge, and 9·83 lbs. in the No. 2 new bridge, the increase of duty being

TABLE VII.

No. 23 Lancashire Boiler, Hand-fired.		Ordinary Bridge.	No. 1 Bridge. (Fig. 2.)	No. 2 Bridge. (Fig. 3.)
		May 1-3, 1889.	May 8-10.	May 14-16.
Coal burnt	lbs.	23,968	18,592	22,624
Water evaporated	gals.	16,772	13,780	15,964
Do. per hour... ...	gals.	347	287	333
Temp. of feed-water (average) ...	degs. F.	118	113	109
Water evaporated	lbs.	166,041	136,592	158,382
Apparent duty	lbs.	6·93	7·35	7·00
Corrected duty	lbs.	7·77	8·28	7·93
Theoretical or adjusted duty ...	lbs.	9·35	9·82	9·83
Coal burnt per square foot of fire-grate surface per hour	lbs.	15·13	11·74	14·28
Proportion of ashes	%	16·9	15·7	19·3
Value of fuel per ton	s. d.	3/6	3/6	3/6
Cost of evaporating 1,000 gallons of water at 62 degs. Fahr. ...	s. d.	2/3·1	2/1·5	2/2·8

Note.—Fire-grate surface in No. 23 boiler = 33 square feet.

5·1 per cent., while the evaporation of 347 gallons per hour was diminished merely to 333 gallons per hour, or only 4 per cent. But for the fact that in the test with No. 2 new bridge, the fuel left 19·3 per cent. of ash as compared with 16·9 per cent., probably even this small decrease of evaporation would not have occurred.

It may, therefore, be taken for granted that an arrangement of bridges similar to that in Fig. 3 with Lancashire boilers will increase their duties 5 per cent. without materially affecting their evaporative power.

VII.—Experiments upon a Lancashire Boiler, with Narrow and Wide Spaces between the Fire-Bars.

Owing to the employment of a dirtier coal than that in use when the mechanical stokers were first adopted, it was found that the work got out of each boiler was decreased by this change of fuel. It was determined to increase the air spaces between the fire-bars, and they were enlarged from ¼ inch to ½ inch wide, the effect of which was to increase the fire-bar air space from 3·2 to 6·4 square feet per boiler.

The results of the experiments with this modification are contained in Table VIII.

It will be observed that the effect of changing from the clean to the dirty coal (8·7 per cent. ash to 22·2 per cent.) was to diminish the evaporative efficiency of the boiler from 405 to 366 gallons of water per hour, or from 64·8 H.P. to 58·6 H.P., while the air spaces between the fire-bars remained unchanged. The effect of increasing the air space was to restore, and rather more than restore, the evaporative efficiency which rose to 411½ gallons, or 65·8 H.P. Nevertheless, the actual economy was less than with the other tests, as may be seen by comparing the respective duties.

TABLE VIII.

No. 21 LANCASHIRE BOILER AND THE HENDERSON MECHANICAL STOKER.		Average of Old Tests. Clean Coal. Narrow Air Space	Average of New Tests. Dirty Coal. Narrow Air Space.	Average of New Tests. Dirty Coal. Wide Air Space.
Coal burnt	lbs.	23,263	24,976	29,176
Water evaporated	gals.	19,468	17,570	19,755
Do. per hour	gals.	405	366	411½
Temp. of feed-water (average) ...	degs. F.	134	100	112
Water evaporated	lbs.	191,939	174,644	195,586
Apparent duty	lbs.	8·25	6·99	6·70
Corrected duty	lbs.	9·13	7·99	7·54
Coal burnt per square foot of fire-grate surface per hour ...	lbs.	19·19	20·61	24 09
Proportion of ashes	%	8·7	22·2	23·7
Value of fuel per ton	s. d.	3/6	3/6	...
Cost of evaporating 1,000 gallons of water at 62 degs. Fahr.	s. d.	1/10·8	2/2·8	2/4·0
Theoretical or adjusted duty	lbs.	10·00	10·26	9·86

The dirty coal used in the latter portion of the experiments was analysed by Mr. J. Pattinson, as under:—

Carbon	66·87
Hydrogen...	4·07
Oxygen	5·03
Nitrogen	1·32
Sulphur	2·93
Ash	17·28
Water	2·50
	100·00
Coke	66·3
Volatile matters...	33·7

VIII.—ANALYSES OF FLUE GASES.

During the progress of the following test, samples of the flue gases were taken for analysis from the end of the boiler flue just before it debouches into the main flue, by Professor Bedson:—

TEST MADE 3RD JULY, 1890.

NO. 21 LANCASHIRE BOILER, FITTED WITH THE HENDERSON MECHANICAL STOKER, AND FIRED WITH ROUGH SMALL COAL.

Duration of test	5 hours.
Coal burnt	3,024 lbs.
Water evaporated	2,120 gals.
Do. per hour	424 gals.
Temp. of feed-water (average)	105 degs. Fahr.
Water evaporated	21,051 lbs.
Apparent duty	6·96 lbs.
Corrected duty	7·89 lbs.
Coal burnt per square foot of fire-grate surface per hour	23·95 lbs.
Proportion of ashes	25·9 per cent.
Theoretical or adjusted duty	10·64 lbs.

The writers are indebted to Professor Bedson for the following analyses of the flue gases taken from the end of the flue in No. 21 Lancashire boiler, fired by the Henderson Patent Mechanical Stoker. These samples were taken on the 3rd and 11th July :—

3RD JULY, 1890.

Temperature at point whence flue gases were extracted, 520 degs. Fahr.

Designation of Sample.	A.	B.	C.	D.
When Drawn Off.	12·30–12·44 p.m.	12·50–1·5 p.m.	2·55–3·7 p.m.	3·18–3·33 p.m.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Carbon dioxide	11·27	10·58	8·29	7·91
Carbon monoxide	...	...	...	...
Combustible gas	...	...	...	...
Oxygen	7·17	8·20	10·93	11·47
Nitrogen	81·56	81·22	80·78	80·62
Total	100·00	100·00	100·00	100·00

11TH JULY, 1890.

Designation of Sample.	A_1.	B_1.	C_1.	D_1.	E_1.
When Drawn Off.	3·20–3·38 p.m.	3·45–4·0 p.m.	4·50–5·5 p.m.	5·18–5·35 p.m.	5·40–5·50 p.m.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Carbon dioxide	5·79	6·44	6·30	8·09	5·67
Carbon monoxide ...	...	...	...	...	...
Combustible gas	...	...	...	...	...
Oxygen	13·92	12·99	13·06	11·12	13·54
Nitrogen	80·29	80·57	80·64	80·79	80·79
Total	100·00	100·00	100·00	100·00	100·00
Temp. by pyrometer degs. Fahr.	440	440	420	440	440

It will be noted that the carbon dioxide is lower in proportion on the 11th July than on the 3rd, and the oxygen correspondingly in excess. The temperatures in the flues were also less, and point to a greater quantity of air passing. On both occasions carbon monoxide and other combustible gases were absent, and the combustion of the boilers is practically perfect.

IX.—PYROMETER OBSERVATIONS.

A series of pyrometer observations were made in the flues with a Hopkinson pyrometer, giving the following results:—

Lancashire Boiler Range—

	Degs. Fahr.
End of flue.—Hand-fired boiler	490
„ Mechanical stoking	400

Egg-Ended Boilers—Juckes Fires—

End of flue, No. 5 boiler, 38 feet long by 6 feet diameter	875 and 865
„ No. 6 „ 28 „ 6 „ ...	940

Egg-Ended Boilers.—Hand-Fired—

End of flue, boiler, 41 feet long by 6 feet diameter	780

Another series of observations were made in connection with a Twibell's economizer, which is fixed in the main flue of the Lancashire boiler range, with the following results:—

	Degs. Fahr.
Temperature in flue.—Entrance to economizer	500
„ „ Exit from „	232
Temperature of feed water in pond	68
„ „ after passing economizer	148

In this case the feed pump (8 inches by 12 inches) was going 9 strokes per minute, and theoretically pumping 2·18 gallons per stroke.

A similar series of observations gave:—

	Degs. Fahr.
Temperature in flue.—Entrance to economizer	485
„ „ Exit from „	244
Temperature of feed-water in pond	68
„ „ economizer...	141

With the feed pump going 10 strokes per minute.

Many other most interesting experiments might be suggested in connection with boiler firing. but the writers think that enough has been described for a paper of reasonable length. In commending these ascertained results to the members of the Institution, they would, in conclusion, point out that the comparative tests have been taken under practical working conditions, and for sufficiently long periods of time to eliminate incidental errors, besides which all disturbing factors have been taken into consideration, and their effect discounted so as to arrive at a true comparison.

Mr. STEAVENSON said he had only one suggestion to make in regard to the paper, and that was that there should be a short synopsis or abstract prepared so as to summarise it.

The CHAIRMAN said they were all obliged to the authors of the paper for bringing this important matter before them, and also to Mr. Steavenson for reading it. Unless Mr. Bird had anything further to add, the paper would now be open for discussion.

Mr. BIRD said he had nothing further to add. The manuscript which Mr. Steavenson had read was only compiled a few days ago, and the paper might, therefore, be considered as up to date.

The CHAIRMAN knew that Mr. Bainbridge had had considerable experience with various systems of boilers, perhaps he would kindly make some remarks on the subject of the paper.

Mr. BAINBRIDGE submitted that it seemed rather late in the day to read a paper specially referring to the scope for economy in the firing of cylindrical boilers, as these were now only used on a small scale; probably nobody who had put boilers down during the last twenty years would have put down cylindrical boilers, and it was to these that the experiments applied. He would like to ask Mr. Bird, in regard to the cylindrical boilers, whether he found much difference in the pyrometer experiments after putting in the three bridges; and also as to the effect of raising the bridge itself? It also seemed to him that the authors had not put enough stress on what appeared to be one of the most important points in the paper. In his (Mr. Bainbridge's) experience of mechanical firing, a class of coal was chiefly used containing some 15 per cent. of dirt; some of the coal Mr. Bird mentioned exceeded that, and he thought the authors might have extended their remarks on the advantages of mechanical stoking where the coal produced so much cinder and ash. With regard to the question of mechanical firing, too, it would have been interesting to learn not only the difference between hand-firing and the Henderson system, but also how the Henderson system compared with others. It was rather odd that while Messrs. Armstrong and Bird had hit upon the Henderson as being the best kind in the North of England, in Lancashire the Vickers was looked upon as the best, and in Yorkshire the Proctor. It would be interesting if experiments could be made to test relatively the merits of the three. He was led to believe from the description of the Henderson that it came under the same category as the Proctor. In the case of the Vickers stoker the coal was thrown close to the fire doors, and by becoming coked the tendency to smokelessness was much more marked than in the Proctor and Henderson. The process mentioned in Figs. 2 and 3, Plate I, of trying to improve the economy of Lancashire boilers was, of course, by no means a new idea; the effect of No. 2 process carried out the same idea as that of Mr. Gosling, an engineer who brought out an economizer some years ago, consisting of discs of fire-clay placed within the tube, of about half the diameter of the tube itself, but these fire-clay discs were so easily worn away that they were replaced by metal ones. The Gaslight and Coke Co. of London had a large number of boilers fitted with this process, effecting a saving of some 15 or 20 per cent. The pyrometer test at 490 degs. did not strike him as being quite satisfactory, as with a boiler thoroughly well arranged the temperature of the gases as they left the main flue should not exceed 350 to 400 degs. One mode of setting boilers had not been mentioned, viz.: making the outside flue larger in area, and raising the side flue curve of fire-brick slightly above the level of the water, the effect being a very marked economy of fuel. It was difficult to discuss the large number of figures read; but he gathered from the paper that the Juckes gave about the same result as hand-firing, and the Henderson mechanical stoker much better results.

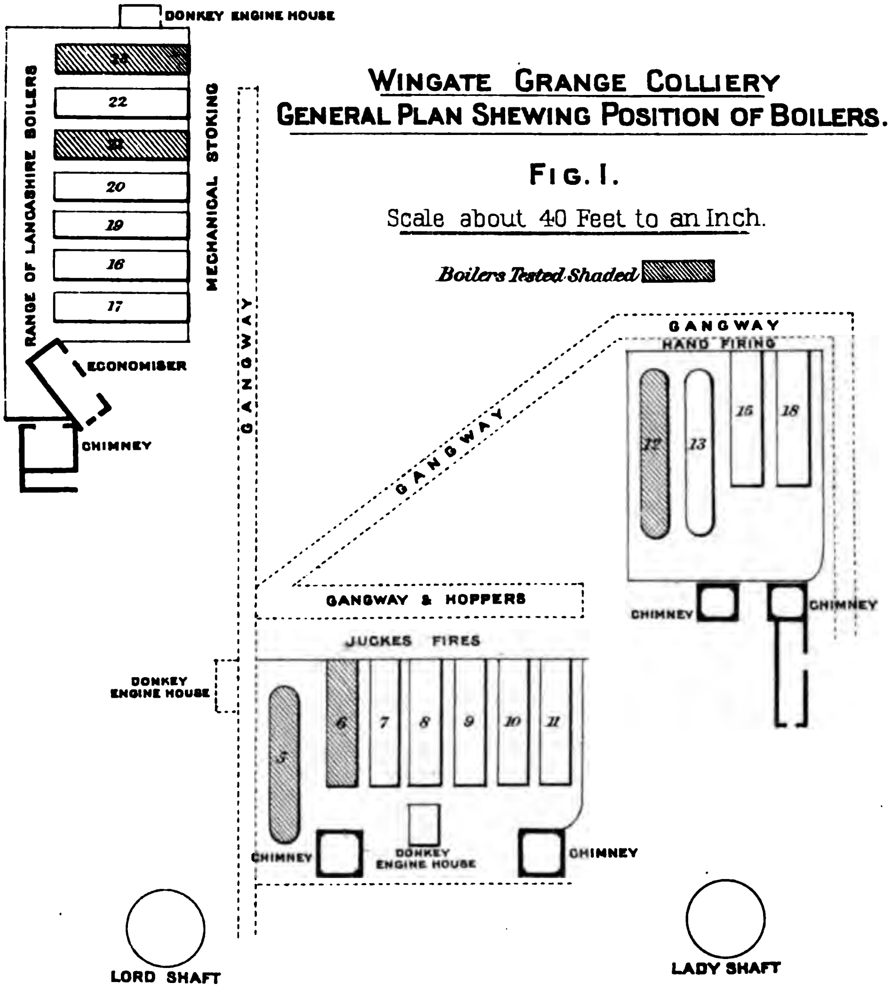
Mr. A. L. STEAVENSON said his experience in testing boilers twenty years ago was with the Juckes fire-bars and with common hand-firing, and he thought the results were that, so far as economy went, there was very little in it, but there was considerable saving in manual labour. The coals were teemed down a long spout, and the labour was reduced to almost nothing; but the difference in evaporation was difficult to detect. He hoped Mr. Bird—who was about to take a distant flight—was only leaving them for a time: but, he trusted, that while he was away he would not forget his friends here, but would send them any notes he could, and he (Mr. Steavenson) would only be too glad to read them for him.

To illustrate Messrs. W. Armstrong jun. and W. J. Bird's paper on "The Economical Working of Steam Boilers at Collieries."

Wingate Grange Colliery
General Plan Shewing Position of Boilers.

Fig. I.

Scale about 40 Feet to an Inch.



Checker Fire Brick Bridges for Tube Boilers

Fig. 2.

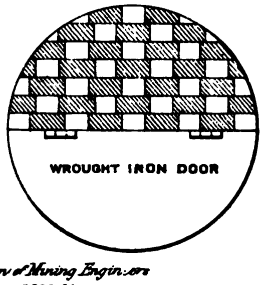
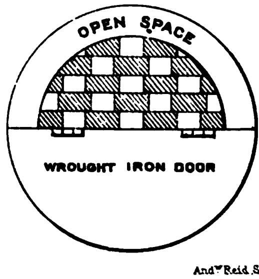


Fig. 3.



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To illustrate Mess.rs W. Armstrong jun. and W. J. Bird's paper on "The Economical Working of Steam Boilers at Collieries."

THE HENDERSON PATENT MECHANICAL STOKER AND SELF-CLEANING FURNACE.

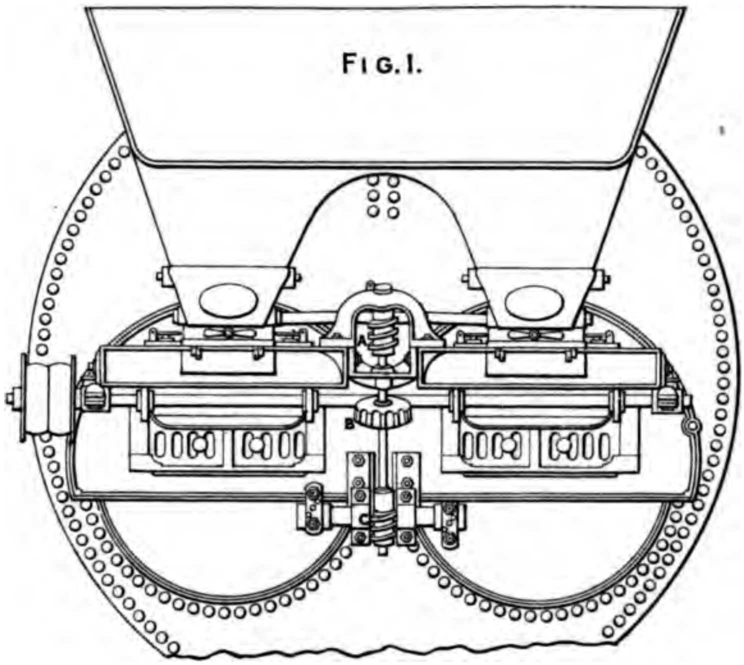

FIG. 1.

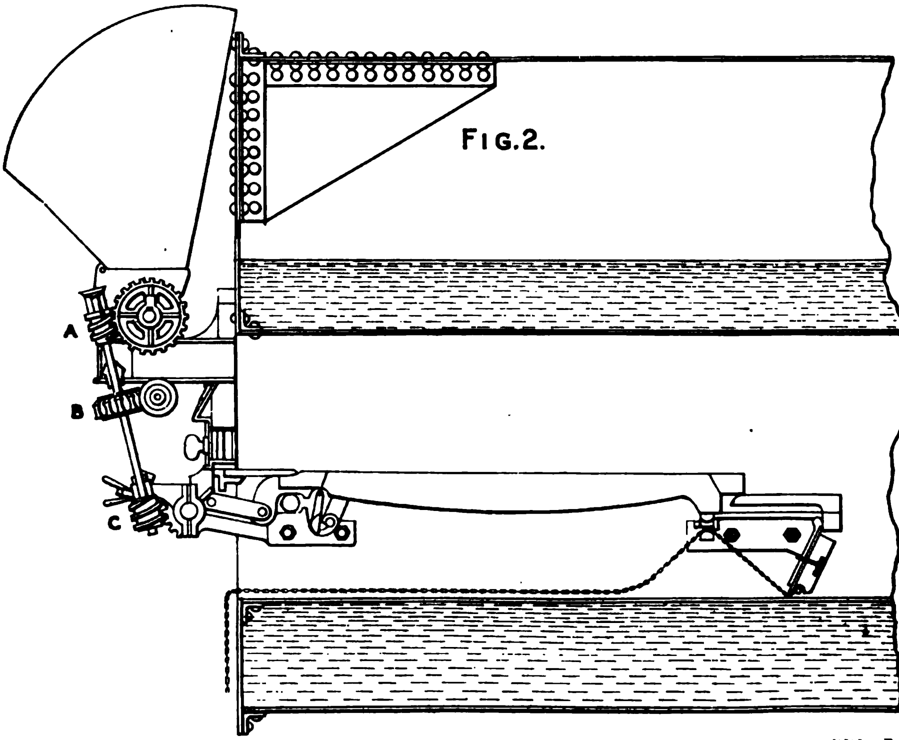

FIG. 2.

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To illustrate Messrs. W. Armstrong jun. and W. J. Bird's paper on "The Economical Working of Steam Boilers at Collieries."

Old Arrangement of Boiler Seating.

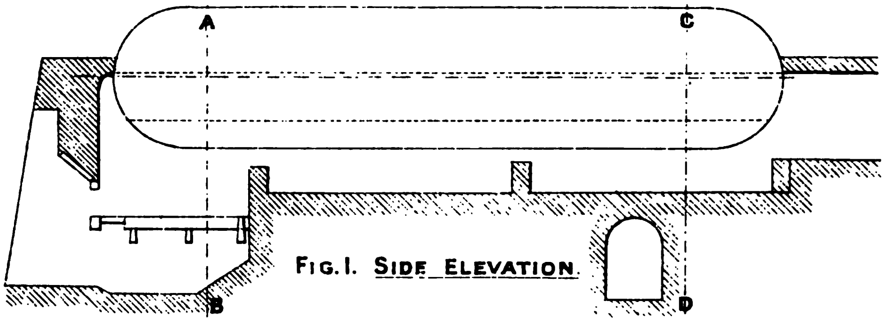


Fig. 1. Side Elevation.

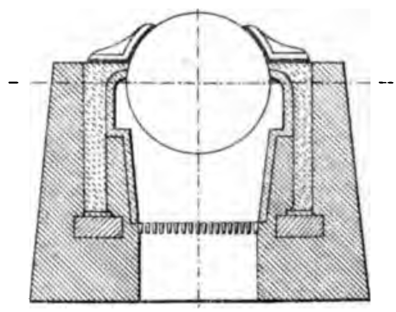


Fig. 2. Section at A B.

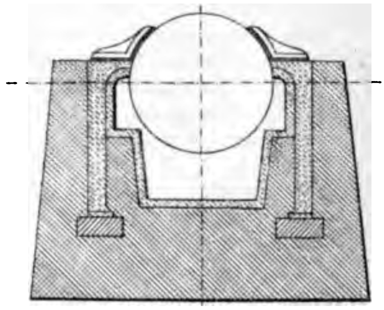


Fig. 3 Section at C D.

New Arrangement of Boiler Seating.

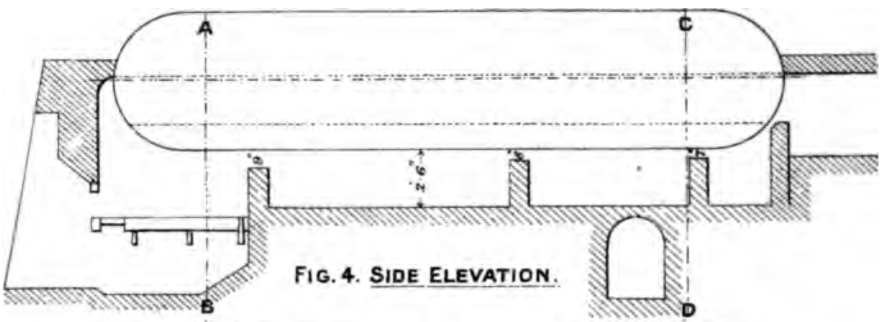


Fig. 4. Side Elevation.

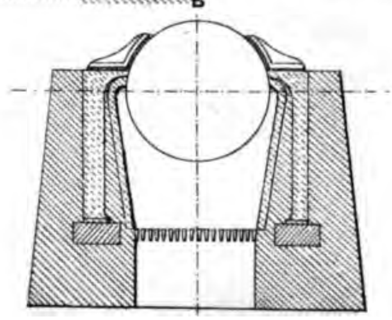


Fig. 5 Section at AB.

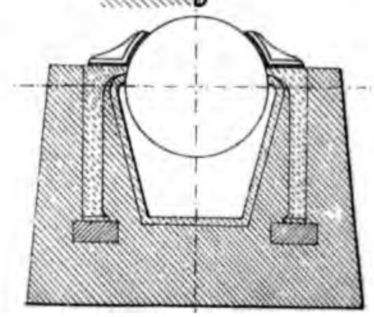


Fig. 6. Section at CD.

Scale ⅛ Inch - 1 Foot.

Andw Reid Sons & Co. Lithos. Newcastle

The CHAIRMAN said he could speak to the merits of the Juckes bars in the reduced boiler repairs and saving of labour. With hand-firing, constantly opening the doors and exposing the front of the boilers to various temperatures were serious objections, which by the use of this system were much reduced, and further, there was entire prevention of the smoke which occurred with hand-firing. He instanced a colliery, where, owing to its being within the limits of a borough it became a difficulty to carry it on, but the adoption of the Juckes furnaces gave entire satisfaction to the authorities, and effected considerable economy. Where coals were cheap or of such a character as to be unsaleable, as was the case at many collieries with a portion of their output, he did not admit that the cylindrical boiler was out of date. Its low first cost and the facility for repairs were strong recommendations. The more costly the boiler, the more difficult and expensive are the repairs. It becomes a question of first outlay and of subsequent expense, as well as economy in fuel, in which latter respect the Lancashire boiler is no doubt an advance upon the cylindrical, but it must, he thought, give way to the type of tubular boilers, of which the Root boiler is an example, for efficiency and economy in evaporative power. He did not think the authors of the paper intended to recommend a similar boiler plant and the use of duff, or small or dirty coal, if they wanted the greatest efficiency, the results attained in pounds of water evaporated per pound of coal being so low; but, in regard to the best utilisation of such fuel at a colliery where it is produced, the record of these experiments is extremely valuable.

Mr. BIRD said Mr. Bainbridge's interesting remarks were prefaced by a statement that cylindrical boilers were practically out of date; of course, he agreed with him in that. Colliery managers were not going to put down cylindrical boilers to any practical extent now; but, as they were in when the experiments were made for the Lancashire boilers, it was very little extra trouble to include them. The pyrometer observations were very incomplete. The pyrometer was only procured during the last week or two, and there was no comparison of the temperature observations available between the old bridge and the new, the pyrometer being got after the new bridge was introduced. The abnormal quantity of ash shown in the experiments with the Juckes fires was due solely to the fact of so much coal going through unburnt, and not, so far as their observations showed, to any actual variation in the quantity of ash. The analysis of the fuel showed a proportion of ash of 17¼ per cent. in the rough small coal, and a little more in the duff coal, whereas the proportion of burnt ash in the experiment with the Juckes fires rose as high as 40 per cent. He quite agreed with Mr. Bainbridge that, in considering the question of mechanical firing, it would be interesting to have a series of comparative tests made with the different kinds of apparatus, under the same conditions; but that was not available at Wingate Colliery, the Henderson being the only one on the premises, unless the Juckes apparatus could be considered a mechanical firer also. Practically, the Juckes firing seemed to give the same results as hand-firing on the boilers; but had the firing been done with cleaner coal—with less ash—he believed the Juckes fires would have shown the full advantage of 12 per cent. which had been worked out theoretically in the paper; and there was no doubt that the life of the boilers under the Juckes fires would be much longer than under hand-firing, for very obvious reasons. Mr. Steavenson very truly pointed out that the advantage of the Juckes system over hand-firing was in the less labour required—a less number of firemen could attend to the same range of boilers. But when the percentage of ash or unburnt fuel increased to so great an extent, and rose to such figures as they found at Wingate, and where that ash had to be moved any considerable distance away, the increased labour in removing the ash neutralised the diminished labour in firing. As Mr. Cochrane said, even the Lancashire boiler, though giving a higher duty than

the cylindrical, was going out of date, and the Roots might be destined in the long run to supersede it. Yet before they reached that Utopian future they would, he thought, have to very considerably modify the quality of water used in colliery boilers. Generally speaking, the experiments had been, as Mr. Cochrane remarked, for the practical adoption of inferior fuel and consequent very obvious economy. He was obliged for Mr. Steavenson's kind offer to read any memoranda he might send home from Persia, and he could only assure him that he would take advantage of it at the earliest opportunity.

The CHAIRMAN said they would accord a vote of thanks to Mr. Bird and Mr. Armstrong for their paper, which would be printed, and open for discussion at a future date. He thanked the members for their attendance; he was sorry there were so few present, but he supposed this was due to the lack of information as to the kind of meeting this was intended to be. They could only by large attendances make the meetings successful. Nottingham had been fixed for the next meeting, on the 24th and 25th of September, and they hoped to have such a programme for that meeting as would satisfy the most exacting of their members.

EDISON PHONOGRAPH.

Through the kindness of Mr. C. R. Johnstone of the Edison United Phonograph Company, the members were given a private representation of the many uses of the phonograph.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
ON SATURDAY, AUGUST 2ND, 1890.

MR. WILLIAM COCHRANE, VICE-PRESIDENT, IN THE CHAIR.

The CHAIRMAN said he was very sorry that the President still remained too unwell to attend this meeting. In a letter he had that morning received from Mr. Marley he was asked to express that gentleman's regret at being unable to attend on the occasion of his retiring from the chair, and to thank the members for the manner in which they had supported him in it; when Mr. Marley was able to come among them again he would possibly address them further. In the meantime, they would all regret the illness which had prevented him from continuing the work which he had so earnestly and zealously done during the time he had been their President. They would all agree in expressing sympathy with Mr. Marley in his illness, and in hoping that he would soon be perfectly restored. It was a pleasure to hear from the Secretary that Mr. Marley (whom he had seen the previous day) was much better, and that there was a prospect of his resuming active work in a short time. With the indulgence of the meeting he (Mr. Cochrane) would do what he could to conduct the business in the President's absence.

The minutes of the last meeting were read and confirmed.

The following gentlemen were declared elected in accordance with the rules of the Institute :—

MEMBER—

Mr. J. R. M. Robertson, M.D., F.G.S., Mining Engineer, Linton, Mitson's Point Sydney.

ASSOCIATES—

Mr. Edward Taylor Cheesman, Colliery Manager, Blaydon Main Colliery, Blaydon-on-Tyne.

Mr. Thomas Rontree, Colliery Manager, Harton Colliery, South Shields.

The following were nominated for election :—

MEMBERS—

Mr. George Bradford, Colliery Viewer, Witton Park, Darlington.
Mr. G. A. Mitcheson, Mining Engineer, Dresden, Longton, Staffordshire.
Mr. William Ryder Stobart, Mining Engineer, Etherley Lodge, Darlington.
Mr. Thomas Watson, Mining Engineer, Trimdon Colliery, Trimdon Grange.

ASSOCIATE MEMBER—

Mr. W. Cochran Carr, Coal Owner, Benwell Colliery, Newcastle-upon-Tyne.

ASSOCIATE—

Mr. Thomas Clark, Under-Manager, Dipton Colliery, Lintz Green.

STUDENT—

Mr. G. M. Andrews, Mining Student, Broomhill Colliery.

The CHAIRMAN then appointed Messrs. A. L. Steavenson, T. O. Robson, R. Thompson, and R. L. Weeks, to act as Scrutineers of the ballot papers for the election of officers for the ensuing year.

The SECRETARY read the annual report of the Council and Finance Committee, as follows :—

THE COUNCIL'S ANNUAL REPORT.

The past year has been an eventful one in the history of the Institute, inasmuch as it has been worked under a new set of rules, and for the first time in close connection with other Institutes of a kindred nature under the Federated Institution of Mining Engineers' scheme.

It is too soon yet to fully appreciate the results due to these changes, but so far as they can judge the Council see no reason to doubt the wisdom of the steps which led to them.

Fifty-two new members of all classes have joined the Institute since the last annual meeting, and 9 have resigned. During the same period there has been a loss by death of 13 members, including, the Council deeply regret to say, some of the best known names connected with mining, such as Mr. E. F. Boyd, Mr. W. Crawford, M.P., Mr. R. Forster, Mr. T. G. Hurst, and Sir Warington W. Smyth.

With Volume XXXVIII. of the Transactions the Institute closes a publication the value of which—from a professional point of view—is now too well established to be dwelt upon. In place of these Transactions members are now receiving, without extra payment, the Proceedings of the Federated Institution of Mining Engineers—in other words, the papers and discussions of this Institute *plus* those of the Chesterfield, Midland, and South Staffordshire Institutes.

Certain special publications have been issued to your members, unconnected with the Proceedings of the Federated Institution of Mining Engineers, such as the "Borings and Sinkings," now nearly completed, Abstracts of Foreign Papers, which it is intended to issue quarterly, and the reports of certain committees to be referred to presently, etc.

In September, a ten days' visit to the Belgian Coal-field and to the Paris Exhibition took place, and much kindness was experienced by the members at the hands of the Belgian coal owners and engineers. In January, the first General Meeting of the Federated Institution brought a large number of members together at Sheffield, where they were extremely well received by the Mayor, Master Cutler, and by their brother engineers of the Midlands, many of whose works and collieries were inspected. The next meeting of the Federated Institution was held in London. in April, in the rooms of the Institution of Civil Engineers, and the Royal Mint and Thames Subway were visited. The third meeting was held in Edinburgh, where the Exhibition was the principal attraction.

The Fan Committee, in which the North of England Institute is united with the South Wales and Midland Institutes, has carried on its work regularly since the date of the last Annual Meeting, and its report is being prepared for the press. The Explosives Committee has also been hard at work, preparing plans, estimates, etc., and in connection with it, the translation of a valuable Report of a French Government Commission will be issued to the members in a few days.

The Council have pleasure in stating that the negotiations with the North-Eastern Railway, mentioned in their last report, have come to a satisfactory termination. The Company will provide an entrance in Orchard Street, and a broad passage lined with glazed bricks adjoining the basement of the Wood Memorial Hall.

In conclusion, the Council feel that they are justified in congratulating the members upon the continued and increasing prosperity of the Institute.

FINANCE REPORT.

The income for the year 1889-90 amounted to £1,509 14s. 2d., being a decrease on that for the previous year of £301 7s. 5d.

The expenditure was £1,433 19s. 2d.—£84 0s. 11d. less than that of the preceding year.

The total receipts for subscriptions and arrears were £1,209 5s. 8d.—£240 16s. 4d. less than last year; this decrease being attributed in a large measure to the fact that fewer finance circulars have been issued to the members this year. The arrears of subscriptions now amount to £207 18s. 0d. as compared with £553 7s. 0d. at the end of last year, of which amount £246 15s. 0d. has been struck off as irrecoverable.

In the ordinary items of expenditure there is a decrease this year of £240 10s. 11d., but against this must be placed the liability of £552 15s. 0d. in respect of subscriptions to the Federated Institution, of which, however, the sum of £223 3s. 5d. appears in the balance sheet as expenses incurred and paid on behalf of that institution. The payment of one hundred guineas in connection with the meeting of the British Association also adds to the year's expenditure, which, however, still compares favourably with that of previous years.

Dr. THE TREASURER IN ACCOUNT WITH SUBSCRIPTIONS, 1889–1890. Cr.

Dr.	£ s. d.	£ s. d.
To 569 Members.		
21 of whom are Life Members—		
Life Member	25 0 0	
31 @ £3 3s.	97 13 0	
517 @ £2 2s.	1,085 14 0	1,208 7 0
548 548		
" 28 Associate Members.		
3 of whom are Life Members—		
25 @ £2 2s.		52 10 0
" 3 Associates @ £1 1s.		3 3 0
" 43 Students—		
42 @ £1 1s.	44 2 0	
1 @ £2 2s.	2 2 0	46 4 0
43 43		
" 10 New Members @ £2 2s.		21 0 0
" 15 New Associates @ £1 1s.		15 15 0
" Subscribing Collieries		92 8 0
		1,439 7 0
" Arrears as per Balance Sheet, 1888–89 ...	553 7 0	
Less—		
Struck out as Irrecoverable	246 15 0	306 12 0
" Resignation withdrawn		2 2 0
" Dividend		0 18 8
		£1,748 19 8

Cr.	£ s. d.	£ s. d.
By Life Member paid	25 0 0	
" 388 Members " @ £2 2s. ...	814 16 0	
" 21 Do. " @ £3 3s. ...	66 3 0	
" 119 Do. unpaid @ £2 2s. ...		249 18 0
" 6 Do. resigned " ...		12 12 0
" 4 Do. gone " ...		8 8 0
" 8 Do. unpaid @ £3 3s. ...		25 4 0
" 1 Do. resigned " ...		3 3 0
" 1 Do. struck off " ...		3 3 0
" 23 Associate Members paid @ £2 2s.	48 6 0	
" 2 Do. unpaid "		4 4 0
" 3 Associates paid @ £1 1s.	3 3 0	
" 1 Student " @ £2 2s.	2 2 0	
" 27 Do. " @ £1 1s.	28 7 0	
" 15 Do. unpaid "		15 15 0
" 8 New Members paid @ £2 2s. ...	16 16 0	
" 2 Do. unpaid " ...		4 4 0
" 14 New Associates paid @ £1 1s. ...	14 14 0	
" 1 Do. unpaid " ...		1 1 0
" Subscribing Collieries paid	88 4 0	
" Do. unpaid		4 4 0
	1,107 11 0	331 16 0
" Arrears paid...	101 14 8	
" Do. unpaid		207 18 0
	£1,209 5 8	£539 14 0

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

		£ s. d.	£ s. d.
July 16, 1889.			
To Balance at Bankers...		481 19 2	
" " in Cashier's hands		40 0 0	
			521 19 2
July 16, 1890.			
To Dividend of 3¾ per cent. on 134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ld., for the half-year ending December, 1889		100 10 0	
" Do., do., 3½ per cent. for the half-year ending June, 1890		93 16 0	
		194 6 0	
" Interest on Investments with the River Tyne Commissioners		73 2 6	
			267 8 6
" *Subscriptions for* 1889-90 *as follows*:—			
388 Ordinary Members at £2 2 0		814 16 0	
21 Do. do. " 3 3 0		66 3 0	
23 Associate do. " 2 2 0		48 6 0	
3 Associates " 1 1 0		3 3 0	
1 Student " 2 2 0		2 2 0	
27 Students " 1 1 0		28 7 0	
8 New Ordinary Members " 2 2 0		16 16 0	
14 New Associates " 1 1 0		14 14 0	
1 Life Member		25 0 0	
		1,019 7 0	
" *Subscribing Collieries, viz.*:—			
Ashington...	£2 2 0		
Birtley Iron Company	6 6 0		
Haswell	4 4 0		
Hetton	10 10 0		
Lambton	10 10 0		
Londonderry	10 10 0		
Marquess of Bute	10 10 0		
North Hetton	6 6 0		
Ryhope	4 4 0		
Seghill	2 2 0		
Stella	2 2 0		
Throckley...	2 2 0		
Victoria Garesfield	2 2 0		
Wearmouth	4 4 0		
Bridgewater Trustees	6 6 0		
Hutton Henry	2 2 0		
North Brancepeth	2 2 0		
		88 4 0	
		1,107 11 0	
" Arrears		101 14 8	
			1,209 5 8
" Sale of Publications, per A. Reid, Sons & Co.... ...		6 16 6	
" Do. Secretary		26 3 6	
			33 0 0
			£2,031 13 4

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.

	£ s. d.	£ s. d.
July 16, 1890.		
By Publishing and Stationery Accounts, viz.:—		
A. Reid, Sons & Co.	31 6 0	
Lambert & Co., Ld.	202 18 0	
		234 4 0
" Books, etc., for Library in addition to above	39 9 9	
" Printing and Stationery do.	26 8 8	
" Abstracts of Foreign Papers	15 12 6	
" Secretary's Incidental Expenses and Postages	83 6 2	
" Sundry Accounts and Payments	11 16 2	
" Travelling Expenses	51 12 5	
" Secretary's Salary	200 0 0	
" Cashier's do.	75 0 0	
" Assistance	4 3 4	
" Clerks' Wages	107 19 2	
" Reporter's Salary	12 12 0	
" Rent	96 18 8	
" Rates and Taxes	21 9 0	
" Fire Insurance	9 4 11	
" Furnishing and Repairs	24 0 2	
" Coals, Gas, and Water	20 14 2	
		800 7 1
		1,034 11 1
" Expenses of Earth Tremor Committee	0 8 0	
" Do. Fan do.	33 4 2	
" Do. Coal Cutting do.	0 12 0	
" Do. Explosives do.	15 15 0	
" Do. Haulage do.	15 0 0	
" British Association Meeting	105 0 0	
" Preparation of Index	6 5 6	
" Federated Institution of Mining Engineers	223 3 5	
		399 8 1
		1,433 19 2
" Balance at Bankers...		510 7 10
" Do. in Cashier's hands	56 17 0	
" Do. Transactions sold...	30 9 4	
		87 6 4
		£2,031 13 4

Audited and found correct,

JOHN G. BENSON,

CHARTERED ACCOUNTANT.

14th October, 1890.

General Statement, July 16th, 1890.

Liabilities.		£ s. d.
Subscription to the Guibal Fund		25 0 0
Subscription to Federated Institution—		
737 Members, @ 15s.	£552 15 0	
Less—Sundry Payments, as per Cash A/c...	223 3 5	
		329 11 7
Capital		11,796 0 1
		£12,150 11 8

Assets.		£ s. d.	£ s. d.
Balance of Account at Bankers		510 7 10	
Do. in Cashier's hands ...	£56 17 0		
Transactions sold	30 9 4		
		87 6 4	
			597 14 2
134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ld.			2,680 0 0
Invested with River Tyne Commissioners ...			2,000 0 0
Arrears of Subscriptions			539 14 0
Value of 558 Bound Volumes of Transactions, @ 11s. 6d.		320 17 0	
4,513 Sewn do., @ 9s.		2,030 17 0	
„ 2,457 Unbound Parts of do., @ 2s.		245 14 0	
„ 79 Copies of Mr. T. F. Brown's Map, @ 5s....		19 15 0	
„ 376 Copies of Index, Vols. 1-25, @ 3s.		56 8 0	
„ 757 Copies of Fossil Illustrations, @ 12s. 6d.		473 2 6	
„ 850 Copies of Catalogue of Fossils, @ 5s....		212 10 0	
„ 1,500 Copies of Borings and Sinkings, Vol. 1 (in Sheets)		300 0 0	
„ 288 Do., Vol. I., @ 5s.		72 0 0	
„ 314 Do., Vol. II., @ 5s.		78 10 0	
„ 331 Do., Vol. III., @ 5s.		82 15 0	
„ 448 Do., Vol. IV., @ 5s.		112 0 0	
„ Sheets of do., Vol. V., unpublished at date		65 0 0	
„ 255 Copies Library Catalogue, @ 5s.		63 15 0	
			4,133 8 6
„ Office Furniture and Fittings ...		450 0 0	
„ Books and Maps in Library ...		1,750 0 0	
			2,200 0 0
			£12,150 11 8

The CHAIRMAN said that in the Finance Report and Statements—which were on the table and could be examined in detail by the members after the meeting—it was stated that the total income for the year was £300 less than that for 1889; this was largely accounted for in the matter of arrears of subscriptions, of which there were large collections in 1889. These arrears having been partly paid, and partly wiped off by the Arrears Committee, left very few arrears to collect during 1890, and whilst the total income from all sources for the year was not so great as it was for the previous year, the Institute was in as flourishing a condition financially as ever, and had, in fact, a net gain in its number of members to the extent of thirty. In this respect they would all agree with him in congratulating the Institute—as the report said—upon its "continued and increasing prosperity." The Council of the Federated Institution was now considering the subject of the mode of printing the Proceedings, which they would all consider at present to be unsatisfactory. There were, as they knew, two forms of publications printed in different type, a selection being made by the Council of the Federated Institution of the papers to appear in each. In one of these the discussions were printed verbatim, and it was thought undesirable to spend so much money in publishing these discussions; those of similar institutions were generally concentrated into the remarks of a speaker once on each subject, but in the Transactions of the Federated Institution they would sometimes see on one page many short remarks from one speaker. This was inconvenient and expensive to print; so much so, that it was felt undesirable to print the discussions in full as at present. The subject was under consideration, and some proposals would, no doubt, be submitted to the members shortly when the Council had decided what was best to be done. The principal point to call attention to in the annual report of the Council was as to the number of meetings. He was one of the very few members who went to Edinburgh—only twenty-eight in all, and these were never all together at one time—and it seemed to him that the great machinery of the Federated Institution of Mining Engineers having been put into operation to obtain the attendance of twenty-eight members from all the institutes, at Edinburgh, where the Exhibition was expected in itself to be a great attraction, the result was extremely disappointing. The Council of the North of England Institute had thought it well to discuss this question, and to consider whether four meetings a year were more likely to succeed when the members of all the institutes—except of that which was located at the place of meeting—were called upon to leave their homes. He would be glad to hear the observations of the members on this or on other subjects of the reports; and in order to put the matter formally he proposed that the reports as presented be adopted.

Mr. WILLIS (H.M. Inspector of Mines) seconded the motion.

Mr. SIMPSON said he had not thought of the subject; but if the meetings were not better attended than that at Edinburgh he was afraid that even four would be too many. He did not know whether it would be wise to come to any conclusion at present, or to wait and see the result of another year. He supposed it would have to be brought before the Council of the Federated Institution for further consideration.

The CHAIRMAN thought that the Council of the Federated Institution would have their revised rules ready by September; they could then be discussed at the Nottingham meeting, which was fixed for the 24th and 25th of September.

Mr. SIMPSON suggested that it would not be proper for this meeting to come to any conclusion.

The CHAIRMAN—Except as a recommendation, which the Council of this Institute could bring before the Council of the Federated Institution, showing what the members of the North of England Institute thought desirable to be done.

Mr. SIMPSON—How would two meetings in the year do?

The CHAIRMAN—The Council to-day thought two would be enough.

Mr. WILLIS thought four too many.

The CHAIRMAN—Shall the Council be instructed to represent to the Federated Institution that they consider two meetings in the year sufficient?

Mr. THOS. BELL (H.M. Inspector of Mines) said he would propose that it be referred to the Council to take into consideration whether two meetings per annum would not be sufficient. The Chesterfield Institute met four times in the year, and the North of England Institute meetings had been reduced from monthly to bi-monthly. He was not sure whether they would not get better local attendances if even this were altered to quarterly meetings. He would at all events propose that the Federated Institution should only meet twice during the year. The question of the General Meetings of this Institute might be left for future consideration.

Mr. SIMPSON seconded the proposal to refer the question to the Council, with a recommendation that there be only two meetings each year.

The resolution was carried unanimously.

The CHAIRMAN called upon Professor Lebour to read Mr. Marley's paper "On the South Durham Salt-field."

Mr. THOS. BELL remarked that no abstract of the paper had been issued, neither were there printed copies of the paper on the table.

The SECRETARY replied that, although it might have been possible to prepare a short abstract the paper itself could not be printed for the meeting, as was done formerly, owing to the fact—before-mentioned—of the papers being referred to a committee, who had to decide in which type it should appear.

The CHAIRMAN said this was one of the inconveniences which had been felt, and he hoped the subject of the publications would be brought before the Council of the Federated Institution at an early date.

ON THE CLEVELAND AND SOUTH DURHAM SALT INDUSTRY.*

By John Marley.

In 1863, at the Newcastle-upon-Tyne meeting of the British Association, the writer read a short paper setting forth the then recent discovery at Middlesbrough, in Cleveland, of rock salt by Messrs. Bolckow & Vaughan, showing how they, in July, 1859, in their search for fresh water for the use of their Middlesbrough iron-works, had commenced the sinking of a shaft, which they sank to a depth of 178 feet into the New Red Sandstone. From the bottom of this they began, on December 31st, 1861, a boring, 18 inches in diameter, by one of Messrs. Mather & Platt's boring machines, their object still being fresh water, and after repeated warnings, both before and during their operations, that salt water was more likely to be got than fresh, they, at a depth of 1,206 feet, touched the top of the rock salt, proving it to be 100 feet thick (Section XVI.). The boring itself was stopped on or about September 10th, 1863. This was the first public announcement of this great geological and commercial fact. To this 1863 paper, which contained a full description of the boring machine and a coloured section of the strata sunk and bored through, was attached an analysis of the lightest coloured sample of the rock salt, representing about one-half of the whole bed. It was then admitted to be impossible to attempt any predication of the area of the salt, but as bearing thereon, the extension of the South Durham Coal-field from Castle Eden and South Wingate, and the fact of the existence of the Lias and Oolitic formations south of Middlesbrough were mentioned. Besides the question of the area of the salt deposit, it was also admitted that it was speculative to attempt to estimate the great commercial results that were expected to the district of the Tyne and the district generally. A period of 26 years having elapsed since this discovery and since the last meeting of the British Association at Newcastle, during the first 11 years of which the matter lay dormant, South Durham has now become a salt-producing district of vast commercial importance.

The question of salt in this district cannot be said to be a recent one, as the Rev. George Young in 1828 in his *Geology of the Yorkshire Coast* mentioned the possibility of rock salt similar to that of Cheshire and Worcestershire being found in the vale of the Tees; next, Mr. G. C. Greenwell in his *Mining Engineering* (1853), in mentioning the Red Sandstone in the north-east part of Yorkshire, said it was by no means improbable that beds of rock salt might be found.

The British Association made an excursion from Newcastle-upon-Tyne to Messrs. Bolckow & Vaughan's salt boring in 1863, and to Messrs. Bell Brothers' works at Port Clarence, from York in 1881. After 1863, the salt question practically lay untouched till 1874, speculation being deterred by the depth at which the rock salt lay and the heavy water-bearing strata to be passed through, involving large capital outlay for sinking, and having regard also to the unknown extent of the area of the deposit, and the consequent uncertainty of suitable return on the capital invested.

Messrs. Bell Brothers' experimental or trial boring in 1874 (Section XI.) having proved that the rock salt continued to the north of Messrs. Bolckow & Vaughan's first boring, they adopted the Continental plan of a fresh-water column balancing the brine column at a point within 200 feet of the surface, accompanied with ease of pumping, and thus became the pioneers of the manufacture of salt in the district.

Mr. Thomas Bell, of Messrs. Bell Brothers, had suggested, and the firm had considered the practicability of raising salt by means of the two columns of water, viz., 1,200 feet of fresh water to 1,000 feet of brine, and on further enquiry it was

* This paper was read before the British Association, at the Newcastle Meeting, in 1889.

found that the plan in question was already in operation near Nancy, in France, where its details were investigated by the heads of the firm and their staff. Afterwards, with the possibility of finding coal, Messrs. Bell Brothers continued the boring for 150 feet, and proved the existence of the Magnesian Limestone below the rock salt.

The writer does not consider it necessary to enter into the details of the respective borings for the rock salt nor of the various modes adopted in the preparing and obtaining of the brine, and of pumping the same to the surface, as these, as well as the modes of manufacture of the salt, have been treated of fully by other writers, to whom reference is made below according to date.

By Mr. W. H. Peacock, mining engineer, on the New Red Sandstone of Cleveland and the rock salt then discovered. This paper was read before the Cleveland Literary and Philosophical Society in 1869.

By Sir Lowthian Bell in 1881 in his paper for the British Association on the industries of Middlesbrough; but more especially in his elaborate paper on the manufacture of this salt, which was read before the Institute of Civil Engineers in May, 1887.

By the late Mr. Thomas Allison, of Guisbro', in April, 1882, in his paper on the "Geology of Middlesbrough and the Surrounding District."

By Mr. T. Hugh Bell, in 1883, before the Cleveland Institute of Engineers, on these salt deposits and the mode of winning them.

By the said Mr. T. Hugh Bell, on these salt deposits, in September, 1883, in his notes for the Iron and Steel Institute meeting at Middlesbrough.

By Mr. T. W. Stuart, on the Tees salt industry, in his paper read in October, 1888, at the Durham College of Science, and published in the Journal of the Society of Chemical Industry for the same month. This paper treats fully of the American system of boring, and of all details connected with the salt.

By Mr. W. J. Bird on this salt bed and associated strata, read before the Manchester Geological Society in June, 1888.

The writer therefore considers it would be a waste of time to repeat in detail that information which can be obtained by reference to these various papers, but wishes more especially, 1st, to direct attention to the extreme north, west, south, and east points of the deposit proved, with the various thicknesses, viz.:—

The last boring (VI.) in a northerly direction in which rock salt is proved at Greatham (see Plate LIV.), which proved salt 82¾ feet thick at a depth of 971 feet 9 inches, there being no salt proved at borings I., II., III., IV., and V., farther to the north.

By way of illustration of the form of this basin of salt as far as known, the Lackenby boring (XXI.) being the deepest, the bottom of the salt being 1,804 feet from the surface, and taking this as the datum-line (as the slight difference of surface-level is too trivial to be taken into account); the rise from XXI. (Plate LIV.) or Lackenby to VI. or Greatham, a distance of about 4 miles, is 832 feet 3 inches, XXI. being as yet the easternmost position of the salt proved.

Then the westernmost point is at Stone Marsh or XXIX. (Plate LIV.), a distance of about 4½ miles, with salt of a thickness of 9 feet, and a rise of 1,011 feet from Lackenby.

From Lackenby (XXI.) to South Bank (XX.), a distance of about 1 mile, with salt 82½ feet thick, and a rise of 151 feet 9 inches.

Next from XX. (Plate LIV.) or South Bank to XVIII. or North Ormsby, a distance of 2½ miles, with salt 89½ feet thick, and a rise of 216 feet 3 inches, as the southernmost point. This southernmost point XVIII. or North Ormsby, and the easternmost point XXI. or Lackenby, are clearly not the termination of the salt basin in these directions.

The several papers from the respective authors, in describing the various geological features, have brought into view differences of opinion on the geological questions, and amongst others a paper on "The Durham Salt District," in the North of England, by Edward Wilson, F.G.S., and published in the *Quarterly Journal of the Geological Society;** and since then another paper by Mr. Howse on these geological points, and read by him in 1888 before the Tyneside Naturalists' Field Club.

Having shown the position and form of the basin, the writer will now call attention to the boring at the westernmost point, viz., XXIX. (Plate LIV.) or Stone Marsh, where only 9 feet of salt was proved, part of that being mixed with gypsum. This was abandoned after boring into Magnesian Limestone to a depth of 178½ feet, or a depth from surface of 1,000 feet, this boring being taken to prove the westernmost outcrop.

Next, attention is called to the Seaton Carew boring IV. (Plate LIV.), where it was proved that salt rock did not exist at the point expected, viz., at a depth of 497 feet. But at 606 feet rock oil was found, and sulphurous water was met with, and at 1,153 feet a brine feeder was got. The salt bed being usually met with between the main beds of anhydrite, this boring was then continued through the Magnesian Limestone at 1,400 feet, proving 878 feet thickness of this rock; and the boring has been continued to a total depth of 1,814 feet 6 inches, and Carboniferous strata proved below the Magnesian Limestone. These, with the 10 inches and 14 inches coal-seams, all form elements for consideration as to their exact geological position.

The next boring to which attention is called is at the point marked XXII., near to the river Tees, where the Newcastle Chemical Co. only got either some few feet of salt, or as some say, none; after proving 167 feet of Magnesian Limestone to a depth of 1,260 feet, this was abandoned, the position of the boring being almost in a direct line from Messrs. Bolckow & Vaughan's first boring, XVI., where salt is of great thickness, and that at Stone Marsh, XXIX, where salt, only 9 feet thick, rendered the absence of salt at XXII. as being most probably due to an underground dislocation and not to an outcrop. Another boring (XXX.) made near Norton by the diamond drill, proved gypsum and anhydrite, but did not prove salt, and after going through the Magnesian Limestone at 760 feet 8 inches depth, the boring was stopped in sandstone and shale.

The production of salt for the years 1887, 1888, 1889, 1890, and 1891 was as follows:—

District.	1887.	1888.	1889.	1890.	1891.
Salt from Brine.					
England—	Tons.	Tons.	Tons.	Tons.	Tons.
Cheshire	1,619,452	1,624,243	1,342,896	1,440,088	1,335,821
Durham	119,477	173,160	191,647	199,971	200,507
Lancashire	......	......	......	7,877	26,867
Staffordshire ...	5,810	5,810	6,450	7,135	6,098
Worcestershire ...	252,000	267,000	217,798	267,348	202,643
Yorkshire	16,790	17,900	26,500	35,700	50,042
Scotland	......	......	......	......	......
Ireland	......	......	......	......	......
Total	2,013,529	2,088,113	1,785,291	1,958,119	1,821,978
Rock Salt.					
England—Cheshire	150,267	182,804	141,063	159,088	184,284
Ireland	30,155	34,652	20,142	29,642	37,309
Gross Totals ...	2,193,951	2,305,569	1,946,496	2,146,849	2,043,571

* Vol. xliv., 1888, page 761.

The salt area proved can be safely taken at 20 square miles, and would produce, if only 90 feet of thickness be taken, 115,200,000 tons of salt per square mile, and as the works on the Tyne consumed about 1 acre per annum, if there be 20 square miles of salt area, there is a supply available for 12,800 years.

The questions of the form of cavities produced by the pumping of the brine, and of possible subsidence of the surface in the future, may be left untouched at present by the writer, but it may be mentioned that the abandonment of the artificial supply of water in the making of brine, and the adoption of self-contained springs may unintentionally be the means of avoiding legal questions as to damages, if any, and also of the pumping of brine from adjoining lands.

Attached are copies of borings. (See Appendices A and B.)

APPENDIX A.

SECTIONS OF BOREHOLES IN SOUTH DURHAM AND CLEVELAND.

I.—*Diamond-boring at the Warren Cement Works, near Hartlepool, by Mr. John Vivian, 1888.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Sand	22	0	22	0
2	Soft mud and peat	8	0	30	0
3	Red clay	18	0	48	0
4	Red pinnel, with small cobbles ...	6	0	54	0
5	Dark pinnel and cobbles	18	0	72	0
6	Pinnel and cobbles	2	0	74	0
7	Dark pinnel and cobbles	19	0	93	0
8	Red clay	2	0	95	0
9	Soft limestone ...	1	0	96	0
10	Red clay	1	0	97	0
11	Hard rock	1	5	98	5
12	Anhydrite	265	7	364	0
13	Dark grey limestone	38	0	402	0

II.—*Diamond-boring at Messrs. Smalley's, Pulp or Cellulose Works, near West Hartlepool.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Depth of well ...	37	0	37	0
2	Dark brown pinnel	13	0	50	0
3	Yellow clay ...	3	0	53	0
4	Coarse soft limestone	4	0	57	0
5	White limestone ...	1	0	58	0
6	Coarse, porous, yellowish-white limestone ...	19	0	77	0
7	Yellowish-white limestone ...	9	0	86	0
8	White limestone ...	102	0	188	0
9	Dark brown limestone ...	4	0	192	0
10	Dark shaly limestone	33	0	225	0
11	Yellow limestone ...	12	0	237	0

III.—*Diamond-boring at the Cement Works, West Hartlepool, for Mr. C. T. Casebourne.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Well previously sunk	30	0	30	0
2	Red sandstone ...	9	0	39	0
3	Red sandy marl ...	10	0	49	0
4	Red sandstone, with beds of red marl	31	0	80	0
5	Red sandstone and marl mixed ...	57	0	137	0
6	Red marl, with beds of red sandstone	27	0	164	0
7	Red and grey sandstone, with beds of red marl... ...	26	0	190	0
8	Red sandstone ...	25	0	215	0
9	Red marl	35	0	250	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
10	Red marl, with beds of sandstone ...	20	0	270	0
11	Red marl	38	0	308	0
12	Red marl, with thin beds of red sandstone	32	0	340	0
13	Red marl	45	0	385	0
14	Red marl, with veins of gypsum ...	95	0	480	0
15	Red marl, with veins of gypsum and blue joints ...	55	0	535	0
16	Red marl, with blue joints	4	2	539	2
17	Red marl, with veins of gypsum and blue spots ...	4	6	543	8
18	Red marl, with veins of gypsum and blue joints ...	24	10	568	6
19	Red marl, with veins of gypsum and red sandstone ...	10	0	578	6
20	Strong marl, with thick veins of gypsum	21	6	600	
21	Red marl, with veins of gypsum and blue joints ...	5	6	605	6
22	Anhydrite	4	0	609	6
23	Anhydrite, with veins of gypsum	12	0	621	6
24	Anhydrite	2	6	624	0
25	Blue marl	0	8	624	8
26	Red marl, with blue joints and veins of gypsum ...	27	10	652	6
27	Anhydrite	7	0	659	6
28	Anhydrite, with black joints, and veins of gypsum	11	0	670	6
29	Anhydrite, with black joints ...	16	0	686	6
30	Anhydrite, with spots of gypsum	18	6	705	0
31	Anhydrite, with gypsum ...	9	4	714	4
32	Anhydrite, mixed with limestone ...	15	8	730	0
33	Limestone, with gypsum	40	0	770	0

IV.—*Diamond-boring near Seaton Carew, by Mr. John Vivian, for Mr. C. T. Casebourne, 1887-1888.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Brown clay... ...	6	0	6	0
2	Red clay	6	0	12	0
3	Red pinnel and cobbles	6	0	18	0
4	Soft red sandy marl	12	0	30	0
5	Red sandy marl ...	3	0	33	0
6	Red and grey sandstone	7	0	40	0
7	Red marl	2	0	42	0
8	Grey sandstone ...	5	0	47	0
9	Red marl, with beds of sandstone ...	10	0	57	0
10	Red sandstone ...	20	0	77	0
11	Grey sandstone ...	2	0	79	0
12	Red sandstone ...	13	0	92	0
13	Grey sandstone ...	1	0	93	0
14	Red sandy marl ...	47	0	140	0
15	Red and grey sandstone	10	0	150	0
16	Red marl	15	0	165	0
17	Red marl, with beds of grey and red sandstone ...	8	0	173	0
18	Red marl, with blue joints	35	0	208	0
19	Red marl, with blue joints and beds of grey sandstone ...	24	0	232	0
20	Red marl, with beds of grey marl ...	33	0	265	0
21	Red marl, with blue joints	24	0	289	0
22	Red marl, with blue joints and veins of gypsum ...	171	0	460	0
23	Red marl, with veins of gypsum	7	5	467	5
24	Anhydrite	13	0	480	5
25	Blue marl, with veins of gypsum	3	0	483	5
26	Anhydrite	1	0	484	5
27	Red marl, with veins of gypsum (rotten marl)	10	0	494	5
28	Dark marl and gypsum mixed ...	2	7	497	0
29	Anhydrite, with black joints ...	25	0	522	0
30	Magnesian limestone, with spots of gypsum ...	27	0	549	0
31	Light grey magnesian limestone, with spots and veins of gypsum	38	0	587	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
32	Dark grey limestone, with spots and veins of gypsum	16	0	603	0
33	Dark blue shale (with small feeder of rock oil and sulphur water) ...	3	0	606	0
34	Anhydrite, with beds of dark blue shale and gypsum ...	35	0	641	0
35	Light grey limestone and gypsum	7	0	648	0
36	Blue shale	2	0	650	0
37	Light grey limestone	11	0	661	0
38	White limestone ...	90	0	751	0
39	Hard white limestone, with gypsum	12	0	763	0
40	Dark grey limestone and anhydrite ...	20	0	783	0
41	Light grey limestone, with gypsum	18	0	801	0
42	Light grey limestone	29	0	830	0
43	Limestone and gypsum mixed ...	31	0	861	0
44	Grey limestone, with gypsum ...	11	0	872	0
45	Light grey limestone and gypsum	33	0	905	0
46	Light grey limestone	50	0	955	0
47	Light grey limestone, with spots of gypsum ...	45	0	1,000	0
48	White limestone ...	107	0	1,107	0
49	Light grey limestone	23	0	1,130	0
50	Broken light grey limestone, and brine spring ...	23	0	1,153	0
51	Light grey limestone	9	0	1,162	0
52	Light grey limestone, with spar cavities	9	0	1,171	0
53	Light grey limestone	7	0	1,178	0
54	White limestone ...	82	0	1,260	0
55	Light grey limestone, with a little gypsum	23	0	1,283	0
56	Dark grey limestone, with gypsum ...	17	6	1,300	6
57	Dark grey limestone, with veins of gypsum ...	19	6	1,320	0
58	Dark limestone, with spots of gypsum	40	0	1,360	0
59	Dark grey limestone	40	0	1,400	0
60	Dark grey shaly sandstone ...	10	0	1,410	0
61	Red and grey shaly sandstone ...	17	6	1,427	6
62	Black shale ...	0	6	1,428	0
63	Dark grey shale ...	1	0	1,429	0
64	Dark grey sandstone	1	0	1,430	0
65	Grey sandstone, with black joints ...	30	0	1,460	0
66	Grey sandstone ...	10	0	1,470	0
67	Very coarse grey sandstone ...	15	0	1,485	0
68	Dark grey sandstone	0	6	1,485	6
69	Black shale ...	0	6	1,486	0
70	Red and grey sandstone	1	7	1,487	7
71	Black shale ...	12	4	1,499	11
72	Shaly sandstone ...	2	6	1,502	5
73	Black shale ...	10	0	1,512	5
74	Grey sandstone ...	4	0	1,516	5
75	Dark grey sandy shale	0	7	1,517	0
76	COAL	0	10	1,517	10
77	Dark brown fireclay	1	2	1,519	0
78	Black sandy shale ...	2	8	1,521	8
79	Dark grey sandy shale	1	8	1,523	4
80	White sandstone ...	26	8	1,550	0
81	Dark grey sandstone	5	0	1,555	0
82	Light grey sandstone	12	8	1,567	8
83	Dark shaly sandstone, with *coal* joints	1	4	1,569	0
84	Black shale ...	9	6	1,578	6
85	COAL	1	2	1,579	8
86	Dark black shale and fireclay ...	0	4	1,580	0
87	White and grey sandstone	6	0	1,586	0
88	Black shale ...	8	0	1,594	0
89	Fine grey sandstone	6	0	1,600	0
90	Dark grey sandstone	3	6	1,603	6
91	Black shale ...	7	0	1,610	6
92	Black shale, with beds of dark grey sandstone ...	6	6	1,617	0
93	Black shale ...	6	0	1,623	0
94	Black shale, with beds of grey sandstone	7	11	1,630	11
95	COAL and shale ...	0	1	1,631	0
96	Dark brown fireclay	2	0	1,633	0
97	Dark grey sandstone	6	0	1,639	0
98	Dark shaly sandstone	5	0	1,644	0
99	Yellowish sandstone	8	9	1,652	9
100	Coarse, light grey sandstone ...	16	6	1,669	3
10	Hard yellowish sandstone, with lime veinule	2	3	1,671	6
102	Coarse, light grey sandstone ...	3	6	1,675	0
103	Coarse grey sandstone	1	6	1,676	6
104	Dark grey shaly sandstone ...	1	6	1,678	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
105	Black shale	8	0	1,686	0
106	Dark grey sandy shale	3	0	1,689	0
107	Dark blue shale	7	0	1,696	0
108	Black shale	4	0	1,700	0
109	Dark brown shale	3	0	1,703	0
110	Grey shaly sandstone	10	0	1,713	0
111	Coarse grey sandstone, with *coal pipes*	24	0	1,737	0
112	Dark grey shaly sandstone	5	0	1,742	0
113	Yellowish shaly sandstone	6	0	1,748	0
114	Dark shaly sandstone	8	0	1,756	0
115	Black shale	24	0	1,780	0
116	Grey sandstone with beds of black shale	10	0	1,790	0
117	Coarse grey sandstone, with black joints	10	0	1,800	0
118	Grey sandstone	14	6	1,814	6

V.—*Boring at Oughton, near Hartlepool.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Gravel, with water	10	0	11	0
3	Blue clay, very strong	54	0	65	0
4	Sand, with water	1	8	66	8
5	Blue clay, very strong	8	6	75	2
6	Red sand	3	6	78	8
7	Sandy clay	5	2	83	10
8	Red sand	8	2	92	0
9	Blue clay	3	10	95	10
10	Sandy clay	1	6	97	4
11	Sand, with water	0	8	98	0
12	Clay, very strong, with pebbles	21	0	119	0
13	Grey freestone tumbler	2	0	121	0
14	Grey sand	4	2	125	2
15	Clay, very strong	1	9	126	11
16	Brown clay, very fine	9	1	136	0
17	Brown freestone	5	0	141	0
18	Grey metal	7	5	148	5
19	Brown post, with gullets	3	0	151	5
20	Red freestone	2	10	154	3
21	White post, very strong	3	0	157	3
22	Red post	12	7	169	10
23	White post, very strong, with metal partings	5	4	175	2
24	Grey metal	1	2	176	4
25	Red freestone	4	1	180	5
26	White post	3	2	183	7
27	Red freestone	15	0	198	7
28	Post girdle	0	9	199	4
29	Red freestone	22	10	222	2
30	Blue metal	3	6	225	8
31	Red freestone	11	0	236	8
32	Blue metal	2	0	238	8
33	Red freestone post	6	0	244	8
34	White post girdle	0	6	245	2
35	Blue metal	1	6	246	8
36	Red freestone post	13	0	259	8
37	White post girdle	0	6	260	2
38	Red freestone post	8	6	268	8
39	White post	6	0	274	8
40	Red metal	12	0	286	8
41	White post girdle	0	6	287	2
42	Red freestone post	6	0	293	2
43	White post girdle	0	6	293	8
44	Red freestone post	17	2	310	10
45	Whin girdle	0	4	311	2
46	Red freestone post	17	2	328	4
47	Strong whin girdle	0	2	328	6
48	Red metal	2	0	330	6
49	Strong whin girdle	0	8	331	2
50	Red metal	3	0	334	2
51	Strong brown post, with metal partings	4	6	338	8
52	Red metal	6	0	344	8
53	Grey metal	3	6	348	2
54	Red freestone post	17	6	365	8
55	Red bastard whin	0	10	366	6
56	Red metal	0	2	366	8
57	Strong whin girdle	0	8	367	4
58	Red metal	9	0	376	4
59	White post girdle	0	4	376	8
60	Red metal	13	8	390	4
61	White post girdle	0	2	390	6
62	Red and white metal	6	2	396	8
63	Red metal	1	6	398	2
64	White post girdle	0	8	398	10
65	White stone, like spar	0	4	399	2
66	Red metal	0	4	399	6
67	Bastard whin girdle	0	6	400	0
68	Red metal	0	2	400	2
69	Bastard whin girdle	0	5	400	7
70	Red freestone post, with metal partings	3	6	404	1
71	Red metal	1	6	405	7
72	Red freestone post	2	7	408	2
73	Red metal	0	4	408	6
74	Brown freestone post	15	8	424	2
75	Red metal	0	8	424	10
76	White post	1	1	425	11
77	Red metal	0	6	426	5

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
78	Brown freestone post	6	6	432	11
79	Red metal	0	6	433	5
80	White post... ...	2	0	435	5
81	Red metal	0	4	435	9
82	Brown freestone post	2	0	437	9
83	Red metal, very strong	1	0	438	9
84	Soft red metal ...	1	2	439	11
85	Brown freestone post	3	10	443	9
86	Red metal	0	8	444	5
87	Brown freestone post	3	4	447	9
88	Strong red metal ...	1	6	449	3
89	Soft red metal ...	0	6	449	9
90	Strong brown post, with a strong feeder of water	3	0	452	9
91	White post girdle...	0	2	452	11
92	Red metal	1	0	453	11
93	White post girdle...	0	10	454	9
94	Red metal and post girdle	14	4	469	1
95	Strong brown post	3	0	472	1
96	Red metal	0	4	472	5
97	**COAL**	0	4	472	9
98	Red metal	1	0	473	9
99	Strong red metal ...	6	0	479	9
100	Strong freestone post	6	6	486	3
101	Soft red metal ...	0	3	486	6
102	Brown whin ...	1	2	487	8
103	Brown freestone ...	0	10	488	6
104	Brown whin ...	5	4	493	10
105	Brown freestone ...	0	7	494	5
106	Brown whin ..	5	7	500	0
107	Whitestone, like spar	0	3	500	3
108	Brown freestone ...	2	9	503	0
109	Brown whin ...	2	6	505	6
110	Strong white post...	4	0	509	6
111	Strong whin post ..	1	1	510	7
112	White whin ...	0	1	510	8
113	Strong whinstone ...	3	11	514	7
114	Strong grey stone...	0	6	515	1
115	Strong blue post ...	1	6	516	7
116	Blue metal	1	3	517	10
117	Brown stone ...	6	7	524	5

VI.—*No. a Diamond-boring at Marsh House, near Greatham, by Mr. John Vivian, for Mr. C. T. Casebourne, 1887 (now Hartlepool Salt and Brine Co., Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Red and blue clay	3	0	4	0
3	Tough red clay ...	26	0	30	0
4	Red sand	4	0	34	0
5	Red sand and clay	15	0	49	0
6	Fine gravel ...	1	0	50	0
7	Brown sandy pinnel	1	0	51	0
8	Brown pinnel and cobbles	14	0	65	0
9	Red sand	2	6	67	6
10	Hard round gravel	4	5	71	11
11	Red sandstone ..	300	7	372	6
12	Red sandstone, with beds of marl ...	77	0	449	6
13	Red sandstone ..	15	2	464	8
14	Red sandstone, with beds of marl ...	114	7	579	3
15	Red sandy marl ...	8	6	587	9
16	Red marl, with blue joints	8	6	596	3
17	Red sandy marl ...	21	3	617	6
18	Red marl	20	3	637	9
19	Red marl, with blue joints	21	8	659	5
20	Red marl, with veins of gypsum ...	18	8	678	1
21	Red marl, with veins of gypsum and blue joints ...	106	11	785	0
22	Red marl, with veins of gypsum and blue spots ..	68	2	853	2
23	Red marl, with veins of gypsum ...	9	10	863	0
24	Anhydrite	11	0	874	0
25	Red marl (rotten)...	15	0	889	0
26	**ROCK SALT** ...	57	2	946	2
27	**SALT** and anhydrite mixed ...	14	3	960	5
28	**ROCK SALT** ...	11	4	971	9
29	Anhydrite	1	0	972	9

VII.—*No. 1 Diamond-boring on Cowpon Marsh, by Mr. John Vivian, for the Newcastle Chemical Works Co., Ltd, 1886 (now United Alkali Co., Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Blue clay	4	0	4	0
2	Dark muddy sand	2	0	6	0
3	Blue sand clay ...	29	4	35	4
4	Soft sand	9	0	44	4
5	Sand and gravel ...	7	0	51	4
6	Rough sand ...	6	0	57	4
7	Clay	0	6	57	10
8	Gravel	0	8	58	6
9	Red pinnel... ...	3	0	61	6
10	Brown clay and cobbles	15	6	77	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
11	Brown pinnel and cobbles	8	0	85	0
12	Hard bound gravel	2	0	87	0
13	Soft red sandstone	6	0	93	0
14	Red sandstone	1	4	94	4
15	Soft red sandstone	40	0	134	4
16	Red sandstone	223	3	357	7
17	Soft marl	0	8	358	3
18	Red sandstone	30	0	388	3
19	Red sandstone, with marl beds	27	4	415	7
20	Red sandstone	207	11	623	6
21	Red marl	3	9	627	3
22	Red marl, with grey stripes	18	1	645	4
23	Red sandstone	13	0	658	4
24	Marly sandstone	35	2	693	6
25	Red sandy marl	13	0	706	6
26	Red sandstone	6	0	712	6
27	Red marl	17	0	729	6
28	Red sandstone, broken	20	6	750	0
29	Red marl	15	0	765	0
30	Red sandstone	9	0	774	0
31	Marly sandstone	7	0	781	0
32	Marly sandstone, with veins of gypsum	20	0	801	0
33	Marly sandstone	16	0	817	0
34	Red marl	23	0	840	0
35	Red marly sandstone	46	0	886	0
36	Red marl, with veins of gypsum	10	0	896	0
37	Red marl	19	0	915	0
38	Marly sandstone, with veins of gypsum	11	0	926	0
39	Red marl, with veins of gypsum	134	0	1,060	0
40	Anhydrite	9	0	1,069	0
41	Red marl, containing a little *salt*	19	6	1,088	6
42	Red marl	2	6	1,091	0
43	**ROCK SALT**	96	0	1,187	0
44	**ROCK SALT** and gypsum	4	0	1,191	0
45	**ROCK SALT**	16	9	1,207	9
46	White stone	3	9	1,211	6
47	Anhydrite	2	6	1,214	0

VIII.—*No. 2 Diamond-boring on Cowpon Marsh, by Mr. John Vivian, for the Newcastle Chemical Works Company, Limited, 1885* (*now United Alkali Co., Ltd.*).

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Brown soil	1	0	1	0
2	Blue clay	1	6	2	6
3	Sand	2	6	5	0
4	Blue clay	4	0	9	0
5	Blue sandy clay	35	0	44	0
6	Sand	10	0	54	0
7	Bound gravel	2	0	56	0
8	Sand and gravel	4	0	60	0
9	Brown clay and cobbles	5	0	65	0
10	Pinnel and large pinnel cobbles	3	0	68	0
11	Sandy pinnel	2	0	70	0
12	Gravelly pinnel and cobbles	7	9	77	9
13	Grey sandstone	2	2	79	11
14	Red sandstone	400	1	480	0
15	Red sandstone, with marl beds	17	0	497	0
16	Red marl	2	0	499	0
17	Red sandstone	70	0	569	0
18	Red sandstone	11	0	580	0
19	Red marl	5	0	585	0
20	Red sandstone	27	0	612	0
21	Red marl	28	0	640	0
22	Red sandstone	16	0	656	0
23	Red sandstone, with marl beds	9	0	665	0
24	Red sandstone	3	0	668	0
25	Broken red marl	5	0	673	0
26	Broken red sandstone	5	0	678	0
27	Red sandstone	12	0	690	0
28	Broken red marl	10	0	700	0
29	Broken red sandstone	14	0	714	0
30	Broken red marl	8	6	722	6
31	Red marl	7	0	729	6
32	Red sandstone	22	0	751	6
33	Red marl	6	6	758	0
34	Red sandstone	3	0	761	0
35	Red marly sandstone	17	0	778	0
36	Red marl	28	0	806	0
37	Red sandy marl	27	0	833	0
38	Red sandy marl, with veins of gypsum	11	0	844	0
39	Red sandy marl	9	0	853	0
40	Red marl, with veins of gypsum	42	4	895	4
41	Red marl	13	8	909	0
42	Red marl, with veins of gypsum	15	0	924	0
43	Red marl	3	0	927	0
44	Red marl, with veins of gypsum	116	0	1,043	0
45	Red marl	13	0	1,056	0
46	Anhydrite	9	0	1,065	0
47	Dark marl	16	2	1,081	2
48	Red marl, containing *salt*	6	4	1,087	6
49	**ROCK SALT**	115	4	1,202	10
50	White stone	7	11	1,210	9
51	Anhydrite	1	3	1,212	0

IX.—*No. 3 Diamond-boring on Cowpon Marsh, by Mr. John Vivian, for the Newcastle Chemical Works Company, Limited, 1885 (now United Alkali Company, Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Blue clay	1	6	2	6
3	Sand	2	6	5	0
4	Blue clay	38	0	43	0
5	Sand	9	0	52	0
6	Sand and gravel ...	4	0	56	0
7	Brown sandy pinnel, with pinnel cobbles	1	0	57	0
8	Red clay and cobbles	5	0	62	0
9	Brown sandy clay, with cobbles ...	12	0	74	0
10	Red sandy pinnel	1	0	75	0
11	Soft red sandstone	3	6	78	6
12	Red sandstone ...	59	6	138	0
13	Grey sandstone ...	4	6	142	6
14	Red sandstone ...	148	6	291	0
15	Broken red marl ...	3	0	294	0
16	Red sandstone ...	201	0	495	0
17	Red marl	4	0	499	0
18	Red sandstone ...	30	0	529	0
19	Red marl	3	0	532	0
20	Red sandstone ...	43	0	575	0
21	Red marl	3	0	578	0
22	Red sandstone ...	5	0	583	0
23	Red marl	4	0	587	0
24	Red sandstone ...	31	6	618	6
25	Red marl	16	0	634	6
26	Red sandstone, very much broken ...	58	6	693	0
27	Red sandstone ...	18	6	711	6
28	Red marl	13	0	724	6
29	Red sandstone ...	23	6	748	0
30	Red marl	9	0	757	0
31	Red sandstone ...	12	0	769	0
32	Red marl	24	0	793	0
33	Marly sandstone ...	20	0	813	0
34	Red marl	19	0	832	0
35	Red marl, with veins of gypsum ...	226	0	1,058	0
36	Anhydrite ...	9	9	1,067	9
37	Broken red marl, very salty ...	8	0	1,075	9
38	Red marl, containing *salt*	13	9	1,089	6
39	**ROCK SALT** ...	101	6	1,191	0
40	Gypsum	1	6	1,192	6
41	Anhydrite	1	0	1,193	6
42	Gypsum, containing *salt*	9	6	1,203	0
43	Anhydrite	2	0	1,205	0

X.—*No. 4 Diamond-boring on Cowpon Marsh, by Mr. John Vivian, for the Newcastle Chemical Works Company, Limited, 1885 (now United Alkali Company, Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Brown sandy clay...	1	6	2	6
3	Sand	2	9	5	3
4	Blue clay	30	9	36	0
5	Brown clay ...	4	0	40	0
6	Sand	9	2	49	2
7	Sand and gravel ...	0	4	49	6
8	Brown pinnel ...	18	6	68	0
9	Brown pinnel, with cobbles	10	8	78	8
10	Soft red sandstone	8	4	87	0
11	Red sandstone ...	50	0	137	0
12	Grey sandstone ...	4	0	141	0
13	Red sandstone ...	43	0	184	0
14	Red sandstone ...	283	6	467	6
15	Red marl	1	0	468	6
16	Red sandstone ...	8	3	476	9
17	Red sandstone, with beds of marl ..	21	9	498	6
18	Red marly sandstone	3	6	502	0
19	Red sandstone ..	27	0	529	0
20	Red marly sandstone	25	0	554	0
21	Red sandstone ...	28	6	582	6
22	Red marly sandstone	1	6	584	0
23	Red marl	4	0	588	0
24	Red sandstone ...	22	6	610	6
25	Red marly sandstone	2	0	612	6
26	Red sandstone ...	9	0	621	6
27	Red marly sandstone	10	6	632	0
28	Red marl	1	6	633	6
29	Red marly sandstone	38	0	671	6
30	Marl	3	0	674	6
31	Red sandstone ...	18	0	692	6
32	Red marly sandstone	6	6	699	0
33	Red sandy marl ...	7	10	706	10
34	Red sandstone ...	7	0	713	10
35	Red marl	6	0	719	10
36	Red sandstone, with beds of marl ...	29	8	749	6
37	Red marl	7	0	756	6
38	Red sandstone and marl	21	6	778	0
39	Red sandy marl ...	32	6	810	6
40	Red marl	30	0	840	6
41	Red marl, with veins of gypsum ...	61	6	902	0
42	Red marl	18	8	920	8
43	Red marl	46	7	967	3
44	Not drawn... ...	18	3	985	6

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
45	Red marl, with veins of gypsum	15	0	1,000	6
46	Red marl	9	0	1,009	6
47	Red marl, with vertical joints of gypsum, ½ in. thick	4	3	1,013	9
48	Red marl	17	3	1,031	0
49	Red marl, with veins of gypsum	15	0	1,046	0
50	Red marl, with gypsum	15	0	1,061	0
51	White stone	0	6	1,061	6
52	Hard white stone	8	6	1,070	0
53	Broken red marl, containing *salt*	6	4	1,076	4
54	Red marl, containing *salt*	12	6	1,088	10
55	Decayed brown marl	1	0	1,089	10
56	Decayed brown marl and *rock salt*	12	2	1,102	0
57	**ROCK SALT**	90	6	1,192	6
58	Gypsum and *salt*	5	6	1,198	0
59	Gypsum and *salt*	4	0	1,202	0
60	Gypsum and *salt*	7	0	1,209	0
61	Gypsum, containing a little *salt*	3	0	1,212	0
62	Anhydrite	2	0	1,214	0

XI.—*No. 1 Diamond-boring at Salt Holme Salt Works, near Port Clarence, for Messrs. Bell Brothers, Limited (now Salt Union, Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Peat, earth and clay	8	0	8	0
2	Blue clay	32	0	40	0
3	Brown and red boulder clay	56	0	96	0
4	Red sandstone	291	0	387	0
5	Grey sandstone	2	0	389	0
6	Red sandstone	57	0	446	0
7	Striped red and grey sandstone	2	0	448	0
8	Red sandstone	19	0	467	0
9	Grey sandstone	2	0	469	0
10	Red sandstone	9	0	478	0
11	Grey sandstone, with 6 inches of red marl	5	6	483	6
12	Reddish grey sandstone	3	6	487	0
13	Red marl, with white stripes	11	0	498	0
14	Red sandstone	38	0	536	0
15	Grey sandstone	4	0	540	0
16	Red sandstone	15	0	555	0
17	Grey sandstone	0	6	555	6
18	Red sandstone	12	6	568	0
19	Grey sandstone	7	0	575	0
20	Red marl, with white stripes	14	0	589	0
21	Red sandstone	18	0	607	0
22	Red marl	8	0	615	0
23	Red sandstone	7	0	622	0
24	Red marl, with white stripes and 2 inches of grey sandy band	14	2	636	2
25	Red sandstone	3	10	640	0
26	Red marl	3	0	643	0
27	Red sandstone	29	0	672	0
28	Red marl	4	0	676	0
29	Red sandstone	24	0	700	0
30	Red marl	2	0	702	0
31	Red sandstone	2	0	704	0
32	Red marl	7	0	711	0
33	Red sandstone	2	0	713	0
34	Red marl	15	0	728	0
35	Grey sandstone	2	0	730	0
36	Red sandstone	6	0	736	0
37	Red marl	5	0	741	0
38	Red sandstone	9	0	750	0
39	Red marl	1	0	751	0
40	Red sandstone	5	0	756	0
41	Red marl, with 2 inches of grey sandy band	10	2	766	2
42	Red sandstone	7	10	774	0
43	Red marl	3	0	777	0
44	Red sandstone	13	0	790	0
45	Red marl, with grey stripes and vein of gypsum	185	0	975	0
46	Hard red marl, with grey stripes and veins of gypsum	21	0	996	0
47	Hard red marl, with thicker vein of pure gypsum	6	6	1,002	6
48	Pure gypsum	1	6	1,004	0
49	Hard white stone	8	6	1,012	6
50	Red sandy marl, rather hard	4	6	1,017	0
51	Red sandy marl, very soft	5	0	1,022	0
52	Red sandy marl, hard, with vein of gypsum	4	0	1,026	0
53	Red and dark brown marl	5	0	1,031	0
54	Red and dark brown marl, with *salt*	12	0	1,043	0
55	**ROCK SALT** and red clay	65	0	1,108	0
56	**ROCK SALT** and gypsum	12	0	1,120	0

XII.—*Trial Diamond-boring on Salt Holme Farm, near Port Clarence, for Messrs. Bell Brothers, Limited, December 15, 1874 (now Salt Union, Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	6	1	6
2	Clay	4	0	5	6
3	Dark sand	7	6	13	0
4	Clean sand	26	0	39	0
5	Red clay	3	0	42	0
6	Sand and gravel	8	0	50	0
7	Boulder clay	27	0	77	0
8	Red marl	73	0	150	0
9	Red sandstone, with veins of marl	144	0	294	0
10	White sandstone	1	3	295	3
11	Red sandstone, with veins of marl	153	9	449	0
12	Red sandstone	10	0	459	0
13	Soft marl	3	0	462	0
14	Red sandstone	6	0	468	0
15	Blue vein	0	10	468	10
16	Red sandstone	31	2	500	0
17	Red sandstone, with veins of marl	27	0	527	0
18	Soft marl	4	0	531	0
19	Red sandstone	29	0	560	0
20	Red sandstone, with veins of marl	49	0	609	0
21	Soft marl	6	0	615	0
22	Red sandstone, with veins of marl	31	0	646	0
23	Red sandstone	6	0	652	0
24	Marl, with blue veins of sandstone	17	0	669	0
25	Red sandstone, with veins of marl	66	0	735	0
26	Blue vein	0	7	735	7
27	Red sandstone, with veins of marl	13	5	749	0
28	Strong mar	9	6	758	6
29	Red sandstone, with veins of marl	26	6	785	0
30	Blue vein	0	3	785	3
31	Strong marl	6	3	791	6
32	Red sandstone, with veins of marl	30	6	822	0
33	Strong red marl and sandstone	17	0	839	0
34	Red sandstone, with veins of marl	16	0	855	0
35	Strong marl	20	0	875	0
36	Red sand and marl	5	0	880	0
37	Red sandstone, with veins of marl	14	0	894	0
38	Strong marl, with veins of sandstone	6	0	900	0
39	Strong marl	23	0	923	0
40	Strong marl, with veins of gypsum	7	0	930	0
41	Mixed marl and sandstone	27	0	957	0
42	Marly sandstone, with veins of gypsum	141	0	1,098	0
43	Gypsum	4	0	1,102	0
44	Hard white stone (yielding gypsum)	3	9	1,105	9
45	Gypsum	3	6	1,109	3
46	Marly sandstone, very *salt*	8	1	1,117	4
47	Sandstone and *salt*	10	3	1,127	7
48	Red rock, with 4 per cent. of *salt*, only 3 ft. of core, because fresh water was used	9	0	1,136	7
49	**GOOD SALT**	16	0	1,152	7
50	**ROCK SALT**	48	5	1,201	0
51	**ROCK SALT,** with marl and gypsum	35	0	1,236	0
52	Soft shale and gypsum	8	0	1,244	0
53	Gypsum	13	0	1,257	0
54	Gypsum and limestone	12	0	1,269	0
55	Magnesian limestone (carburetted hydrogen gas was liberated here)	45	0	1,314	0
56	Grey limestone	9	0	1,323	0
57	Grey limestone and gypsum	11	0	1,334	0
58	Gypsum	2	0	1,336	0
59	Gypsum, containing *salt*	1	0	1,337	0
60	**ROCK SALT**	14	0	1,351	0
61	Marl, containing *salt*	2	0	1,353	0
62	Marl, with gypsum	1	0	1,354	0
63	**SALT,** impure	1	0	1,355	0

XIII.—*No. 1 Boring at Clarence, for Messrs. Bell Brothers, Limited, 1890.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Sandy clay	10	0	10	0
2	Sand	33	0	43	0
3	Sand and gravel	15	0	58	0
4	Sand	1	0	59	0
5	Gravel	5	0	64	0
6	Sand and gravel	3	0	67	0
7	Gravel and pinnel	25	0	92	0
8	Red sandstone	458	0	550	0
9	Sandy marl	62	0	612	0
10	Red sandstone	14	0	626	0
11	Sandy marl	4	0	630	0
12	Red sandstone	16	0	646	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
13	Sandy marl ...	26	0	672	0
14	Sandstone	46	0	718	0
15	Sandy marl ...	39	0	757	0
16	Marl	172	0	929	0
17	Hard white stone	5	0	934	0
18	Marl	34	0	968	0
19	Marl and gypsum	113	0	1,081	0
20	White stone ...	16	0	1,097	0
21	Marl, containing *salt*	15	0	1,112	0
22	**SALT**	88	0	1,200	0
23	**SALT** and marl ...	11	8	1,211	8
24	Blue shale and anhydrite ...	10	0	1,221	8

XIV.—*No. 3 Boring at Clarence, for Messrs. Bell Brothers, Limited, 1890.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Surface	89	0	89	0
2	Marl	52	0	141	0
3	Sand and gravel ...	4	0	145	0
4	Sandstone, with marl beds ...	99	0	244	0
5	Red sandstone ..	30	0	274	0
6	Sandy marl ...	13	0	287	0
7	Sandstone	82	0	369	0
8	Marl and sandstone	104	0	473	0
9	Sandy marl ..	31	0	504	0
10	Sandstone	24	0	528	0
11	Sandy marl ...	27	0	555	0
12	Marl	35	0	590	0
13	Marl and sandstone	79	0	669	0
14	Marl	22	0	691	0
15	Sandstone and marl	21	0	712	0
16	Marl	13	0	725	0
17	Sandy marl ...	51	0	776	0
18	Marl	199	0	975	0
19	Limestone	8	0	983	0
20	Marl	36	0	1,019	0
21	Very soft marl ...	9	0	1,028	0
22	Marl	11	0	1,039	0
23	Marl, with a little gypsum	11	0	1,050	0
24	Marl	9	0	1,059	0
25	Marl and gypsum	28	0	1,087	0
26	Marl	35	0	1,122	0
27	Muddy marl ...	8	0	1,130	0
28	Marl	23	0	1,153	0
29	Marl and gypsum	12	0	1,165	0
30	White stone ..	7	0	1,172	0
31	White stone and marl	8	0	1,180	0
32	Marl	15	0	1,195	0
33	**SALT**	93	0	1,288	0
34	**SALT** and bluish marl	3	0	1,291	0
35	Anhydrite and marl	10	0	1,301	0

XV.—*No. 5 Boring at Clarence, for Messrs. Bell Brothers, Limited, 1892.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Surface	138	0	138	0
2	Red sandy marl ...	42	0	180	0
3	Red sandstone and a little marl ...	90	0	270	0
4	Red sandstone ...	232	0	502	0
5	Red sandstone and red marl... ...	68	0	570	0
6	Red marl	13	0	583	0
7	Red sandstone, with streaks of marl...	34	0	617	0
8	Red marl, with small streaks of sandstone ...	30	0	647	0
9	Red marl	27	0	674	0
10	Red marl, with streaks of sandstone	28	0	702	0
11	Red marl	103	0	805	0
12	Red sandstone ...	20	0	825	0
13	Red marl	105	0	930	0
14	Red marl, with a little sandstone	22	0	952	0
15	Red marl . .	12	0	964	0
16	Red marl, with veins of gypsum	75	0	1,039	0
17	Red marl	31	0	1,070	0
18	Red marl, with veins of gypsum	20	0	1,090	0
19	Red marl and much gypsum	27	0	1,117	0
20	Red marl	6	0	1,123	0
21	White stone ...	11	0	1,134	0
22	Red marl	3	0	1,137	0
23	Broken marl ...	15	0	1,152	0
24	Broken marl, with *salt*	4	0	1,156	0
25	**SALT**	90	0	1,246	0
26	Anhydrite... ...	5	0	1,251	0
27	**SALT**	12	0	1,263	0
28	Anhydrite... ...	2	0	1,265	0

XVI.—*Boring at Middlesbrough for Messrs. Bolckow and Vaughan, by Messrs. Mather and Platt, commenced on July 4, 1859, and completed on August 29, 1862 (now Cleveland Salt Co., Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Made ground ...	11	0	11	0
2	Dry slime or river mud	8	0	19	0
3	Sand, with water...	10	0	29	0
4	Hard dry clay ...	10	0	39	0
5	Red sand, with a little water ...	1	0	40	0
6	Loamy sand, with a little water ...	3	0	43	0
7	Hard dry clay ...	15	0	58	0
8	Rock, mixed with clay and water...	11	0	69	0
9	Rock, mixed with clay	1	0	70	0
10	Rock, mixed with gypsum... ...	6	0	76	0
11	Gypsum, with water	2	0	78	0
12	Red sandstone, with small veins of gypsum, & water	55	0	133	0
13	Rock gypsum ...	6	0	139	0
14	Brown shale, with water	1	0	140	0
15	Red sandstone ...	4	0	144	0
16	Red sandstone, with small veins of gypsum, & water	12	0	156	0
17	Blue sandstone, with water at bottom	3	0	159	0
18	Red sandstone, with water	19	0	178	0
	Bottom of sinking, bored below.				
19	Red sandstone ...	437	4	615	4
20	Red and white sandstone	1	6	616	10
21	Red sandstone ..	215	7	832	5
22	Red sandstone and clay	1	0	833	5
23	Red sandstone ...	52	3	885	8
24	Red sandstone and clay	9	0	894	8
25	Red sandstone ...	66	5	961	1
26	Strong clay ...	2	9	963	10
27	Red sandstone and clay	1	6	965	4
28	Red sandstone ...	27	5	992	9
29	Red sandstone and clay	9	0	1,001	9
30	Sandstone, with a vein of blue rock	49	4	1,051	1
31	Red and blue sandstone	1	5	1,052	6
32	Red sandstone ...	6	0	1,058	6
33	Red sandstone and thin veins of gypsum... ...		5	1,059	11
34	Red sandstone and thin veins of gypsum	39	8	1,099	7
35	Red sandstone, with blue clay and gypsum... ...	1	2	1,100	9
36	Red sandstone, with veins of gypsum	87	3	1,188	0
37	Gypsum	3	2	1,191	2
38	White stone ...	0	8	1,191	10
39	Limestone	2	8	1,194	6
40	Blue rock	0	2	1,194	8
41	Blue clay	0	2	1,194	10
42	Hard blue and red rock	0	10	1,195	8
43	White stone ...	2	7	1,198	3
44	Dark red rock ...	1	2	1,199	5
45	Dark red rock, rather *salt*	6	7	1,206	0
46	**ROCK SALT,** rather dark ...	12	7	1,218	7
47	**ROCK SALT,** very dark	4	1	1,222	8
48	**ROCK SALT,** very light	3	6	1,226	2
49	**ROCK SALT,** rather dark ...	27	4	1,253	6
50	**ROCK SALT,** very light	43	6	1,297	0
51	**ROCK SALT,** rather light ...	9	0	1,306	0
52	Limestone	1	0	1,307	0
53	Conglomerate, resembling limestone, and containing a large quantity of *salt*	6	4	1,313	4

XVII.—*No. 1 Boring at Middlesbrough for Messrs. Bolckow, Vaughan and Company, commenced to pump brine on August 17, 1886 (now Cleveland Salt Co., Ltd.).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft	In
1	Made ground ..	11	0	11	0
2	Dry slime	8	0	19	0
3	Sand, with water...	10	0	29	0
4	Hard dry clay ...	10	0	39	0
5	Red sandstone, with water	1	0	40	0
6	Sand or loam, with water	3	0	43	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
7	Hard dry clay ...	13	0	56	0
8	Mixed rock and clay, with water	11	0	67	0
9	Mixed rock and clay, dry ...	1	0	68	0
10	Mixed rock and clay and gypsum, dry	6	0	74	0
11	Shell of rock with water	2	0	76	0
12	Red and blue rock, with small veins of white gypsum, and water ...	55	0	131	0
13	White gypsum rock, dry	6	0	137	0
14	Brown shale, with water	1	0	138	0
15	Red sandstone ...	4	0	142	0
16	Red sandstone, with small veins of white gypsum ...	12	0	154	0
17	Blue post stone and water	3	0	157	0
18	Red sandstone, with water	19	0	176	0
19	Red sandstone ...	134	6	310	6
20	Marl	6	6	317	0
21	Sandstone and a little marl ...	3	0	320	0
22	Soft red sandstone	35	0	355	0
23	Hard dark red sandstone	9	0	364	0
24	Hard dark red sandstone, a little softer	5	9	369	9
25	Red marl	3	3	373	0
26	Red sandstone, with thin layers of marl	7	0	380	0
27	Hard dark sandstone, with a little mica ...	23	0	403	0
28	Dark red sandstone, with a little mica	9	3	412	3
29	Rough red sandstone	20	3	432	6
30	Rough red sandstone, a little darker	9	6	442	0
31	Fine dark red sandstone	7	0	449	0
32	Rough red sandstone	12	3	461	3
33	Red sandstone, with a little marl ...	19	3	480	6
34	Red sandstone, with kernels of marl...	8	6	489	0
35	Red sandstone, a little harder ...	24	6	513	6
36	Hard red sandstone	8	6	522	0
37	Marl	12	6	534	6
38	Soft red sandstone	34	9	569	3
39	Red marl	9	3	578	6
40	Soft red sandstone	11	0	589	6
41	Hard red sandstone	13	0	602	6
42	Soft red sandstone	4	6	607	0
43	Red marl	13	6	620	6
44	Soft red sandstone, with thin seams of marl	19	9	640	3
45	Hard red sandstone, with a little mica	28	3	668	6
46	Hard red sandstone and marl ...	29	0	697	6
47	Marl	14	6	712	0
48	Red sandstone ...	8	6	720	6
49	Hard red sandstone and marl ...	25	6	746	0
50	Red marl	15	9	761	9
51	Red sandstone and marl	9	3	771	0
52	Soft red sandstone	20	3	791	3
53	Soft red sandstone, with a little marl	5	6	796	9
54	Hard red sandstone, with marl partings	6	6	803	3
55	Hard red sandstone and marl ...	7	9	811	0
56	Soft red sandstone	4	6	815	6
57	Red marl	10	6	826	0
58	Hard red sandstone and marl ...	9	3	835	3
59	Red marl	11	3	846	6
60	Fine dark red sandstone	12	6	859	0
61	Hard dark sandstone, with marl partings ...	11	6	870	6
62	Marl and a little red sandstone ...	6	9	877	3
63	Dark red sandstone	9	3	886	6
64	Marl, with partings of sandstone ...	1	8	888	2
65	Red sandstone ...	7	10	896	0
66	Red sandstone, with marl partings ...	2	0	898	0
67	Red marl	21	6	919	6
68	Hard dark red sandstone	4	6	924	0
69	Hard dark red sandstone and marl...	5	6	929	6
70	Hard red sandstone	4	3	933	9
71	Red marl	21	9	955	6
72	Red sandstone, with veins of marl ...	9	9	965	3
73	Red sandstone ...	5	9	971	0
74	Red marl	43	0	1,014	0
75	Hard red sandstone, with thin layers of marl	8	0	1,022	0
76	Red marl	4	0	1,026	0
77	Hard red sandstone, with grey spots...	2	6	1,028	6
78	Hard sandstone and red marl... ...	11	3	1,039	9
79	Red marl	7	9	1,047	6
80	Hard red sandstone and marl ...	15	0	1,062	6

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
81	Red marl	15	6	1,078	0
82	Hard red sandstone and marl ...	10	9	1,088	9
83	Red marl	5	9	1,094	6
84	Red marl, with thin seams of red sandstone	20	6	1,115	0
85	Hard red marl, with a little red sandstone	9	0	1,124	0
86	Hard red sandstone and marl ...	8	0	1,132	0
87	Very hard red marl	4	6	1,136	6
88	Hard marl and sandstone mixed ...	17	0	1,153	6
89	Hard marl.. ...	15	0	1,168	6
90	Very hard marl and sandstone ...	16	3	1,184	9
91	Magnesian limestone and gypsum rock	2	9	1,187	6
92	Magnesian limestone, much lighter ...	0	10	1,188	4
93	Magnesian limestone*	2	0	1,190	4
94	Band of blue rock...	0	3	1,190	7
95	Red and white rock	0	5	1,191	0
96	Hard gypsum and lime	1	0	1,192	0
97	Red and white rock, rather *salt* ...	14	0	1,206	0
98	Marl and *rock salt*	2	0	1,208	0
99	Hard marl, with blue spots, rather *salt*	5	0	1,213	0
100	Marl and dark coloured *rock salt* ...	7	0	1,220	0
101	**ROCK SALT** ...	66	0	1,286	0
102	Hard red marl and *salt*	0	6	1,286	6
103	Very hard blue marl and *salt*... ...	1	0	1,287	6
104	**SALT** and a little red marl ...	7	3	1,294	9
105	Solid grey gypsum	0	6	1,295	3
106	**SALT** and gypsum	1	0	1,296	3
107	Solid gypsum ...	3	9	1,300	0

* Analysis of No. 93:—Sulphate of lime 27, carbonate of lime 40¼, and carbonate of magnesia 32¾ per cent.

XVIII.—*No. 1 Boring, near North Ormesby Toll Bar, for the Owners of the Middlesbrough Estate, Limited, June, 1887.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Brown clay ...	6	0	6	0
2	Brown clay and stones	24	0	30	0
3	Hard clay and cobbles	4	0	34	0
4	Red and grey marl	5	0	39	0
5	Rotten grey marl...	1	0	40	0
6	Red marl	2	6	42	6
7	Red and grey marl	1	0	43	6
8	Red marl, with veins of gypsum	5	0	48	6
9	Red and grey marl, very hard ...	1	0	49	6
10	Red marl, with veins of gypsum	0	6	50	0
11	Red marl	1	7	51	7
12	Red and grey marl, very hard ...	1	6	53	1
13	Red and grey marl, with veins of gypsum... ...	4	11	58	0
14	Red and grey marl	1	0	59	0
15	Grey marl, with veins of gypsum	7	6	66	6
16	Red and grey marl	2	0	68	6
17	Red marl, with veins of gypsum	12	0	80	6
18	Grey marl, with veins of gypsum	3	0	83	6
19	Red marl, with veins of gypsum	6	6	90	0
20	Grey marl, with veins of gypsum	11	0	101	0
21	Red and grey marl, with veins of gypsum	8	0	109	0
22	Red marl, with veins of gypsum	5	0	114	0
23	Red and grey marl, with veins of gypsum	4	6	118	6
24	Red marl, with veins of gypsum	3	6	122	0
25	Grey marl, with veins of gypsum	1	0	123	0
26	Red marl, with veins of gypsum	14	0	137	0
27	Red and grey marl, with veins of gypsum	11	6	148	6
28	Red marl, with veins of gypsum	12	0	160	6
29	Red and grey marl, with veins of gypsum	10	0	170	6

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
30	Red marl, with veins of gypsum	5	0	175	6
31	Grey marl, with veins of gypsum	4	0	179	6
32	Red and grey marl	25	2	204	8
33	Red and grey marl, with veins of gypsum	21	4	226	0
34	Hard grey marl ...	3	0	229	0
35	Rotten red and grey marl ...	3	0	232	0
36	Red and grey marl, with veins of gypsum	2	6	234	6
37	Rotten red and grey marl	1	0	235	6
38	Red and grey marl, with veins of gypsum	1	6	237	0
39	Red and grey marl	5	0	242	0
40	Blue marl	5	0	247	0
41	Red and grey marl, with veins of gypsum	2	0	249	0
42	Red and grey marl, with veins of gypsum, broken ...	2	0	251	0
43	Blue marl, with veins of gypsum	2	8	253	8
44	Gypsum	1	0	254	8
45	Grey marl, with veins of gypsum	5	10	260	6
46	Red marl	16	6	276	6
47	Red and grey sandstone	4	0	280	6
48	Red sandstone ...	267	6	548	0
49	Red sandstone, broken	41	0	589	0
50	Grey sandstone ...	2	0	591	0
51	Red sandstone ...	10	0	601	0
52	Grey sandstone ...	1	0	602	0
53	Red sandstone ...	147	0	749	0
54	Red marly sandstone	2	0	751	0
55	Red sandstone ...	131	10	882	10
56	Red marl	7	0	889	10
57	Red sandstone ...	57	4	947	2
58	Red sandstone, with small beds of marl	20	6	967	8
59	Red sandy marl ...	7	6	975	2
60	Red sandstone ...	38	10	1,014	0
61	Red marl	7	0	1,021	0
62	Red sandstone ...	1	9	1,022	9
63	Red marl	1	0	1,023	9
64	Red sandstone ...	4	0	1,027	9
65	Marl	0	9	1,028	6
66	Red sandstone ...	7	0	1,035	6
67	Red marl	1	6	1,037	0
68	Red sandstone ...	4	0	1,041	0
69	Red sandy marl ...	15	6	1,056	6
70	Red sandstone ...	17	6	1,074	0
71	Red sandy marl ...	8	1	1,082	1
72	Red marl	8	0	1,090	1
73	Red sandy marl ...	45	11	1,136	0
74	Red sandy marl, with veins of gypsum	12	1	1,148	1
75	Red sandy marl ..	10	3	1,158	4
76	Red marl	20	3	1,178	7
77	Red marl, with veins of gypsum ...	140	2	1,318	9
78	White stone, anhydrite	8	6	1,327	3
79	Red marl, very much broken ...	12	6	1,339	9
80	Marl, containing *salt*	1	2	1,340	11
81	**ROCK SALT** ...	79	1	1,420	0
82	Anhydrous gypsum	6	0	1,426	0
83	**ROCK SALT** ...	10	0	1,436	0
84	Anhydrous gypsum	4	0	1,440	0

XIX.—*Diamond-boring at the Imperial Iron Works, Eston, by Mr. John Vivian, 1887.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Slag...	13	6	13	6
2	Loamy clay ...	1	0	14	6
3	Blue clay	15	6	30	0
4	Sandy clay... ...	12	0	42	0
5	Fine red pinnel ...	6	0	48	0
6	Red pinnel... ...	1	0	49	0
7	Hard brown pinnel	5	6	54	6
8	Hard brown pinnel, with small cobbles	5	6	60	0
9	Brown pinnel ...	6	6	66	6
10	Red marl	6	6	73	0
11	Red and blue marl	33	4	106	4
12	Red and blue marl, with gypsum ...	38	4	144	8
13	Hard blue marl ...	51	5	196	1
14	Blue and red marl	14	3	210	4
15	Red and blue marl, with gypsum ...	6	0	216	4
16	Red and grey sandstone and marl, mixed ...	311	6	527	10
17	Red and grey sandstone	1	9	529	7
18	Red sandstone ...	139	9	669	4
19	Red sandstone, with marl joints ...	106	11	776	3
20	Red and grey sandstone, with marl joints	94	6	870	9
21	Red sandstone, with marl joints ...	102	9	973	6
22	Red sandy marl ...	7	6	981	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
23	Red sandstone, with marl joints ...	65	8	1,046	8
24	Red sandstone, with beds of marl ...	57	7	1,104	3
25	Red marl, with blue spots	16	0	1,120	3
26	Red sandstone, with beds of marl ...	105	11	1,226	2
27	Red marl, with blue spots	13	0	1,239	2
28	Red sandstone, with marl beds ...	26	6	1,265	8
29	Red marl	12	3	1,277	11
30	Red sandstone, with marl beds ...	13	7	1,291	6
31	Red marl	21	0	1,312	6
32	Red sandy marl ...	11	0	1,323	6
33	Red sandstone ...	7	0	1,330	6
34	Red sandy marl ...	3	0	1,333	6
35	Red sandy marl, with blue spots and gypsum joints	21	0	1,354	6
36	Red marl, with veins of gypsum ...	13	0	1,367	6
37	Red marl, with blue spots and veins of gypsum	4	0	1,371	6
38	Red marl, with veins of gypsum ...	0	6	1,372	0
39	Red sandy marl, with veins of gypsum and blue spots	19	9	1,391	9
40	Red marl, with veins of gypsum and blue spots ...	83	3	1,475	0
41	Red marl, with veins of gypsum ...	61	9	1,536	9
42	Anhydrite	14	3	1,551	0
43	Red marl, with a little *salt* ...	11	4	1,562	4
44	Marl and salt ...	25	8	1,588	0
45	**ROCK SALT** ...	48	0	1,636	0
46	Anhydrite	41	6	1,677	6
47	**SALT** and anhydrite, honeycombed ...	12	9	1,690	3
48	Anhydrite	1	9	1,692	0

XX.—*No. 1 Diamond-boring (9⅞-inch hole) at South Bank Iron Works, Eston, by Mr. John Vivian, for Messrs. Bolckow, Vaughan, and Company, Limited, 1885 (now Cleveland Salt Company, Limited).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Made ground ...	6	0	6	0
2	Sandy blue clay ...	10	0	16	0
3	Dark brown clay ...	7	0	23	0
4	Soft red marl ...	2	0	25	0
5	Brown pinnel ...	1	0	26	0
6	Hard brown pinnel	15	0	41	0
7	Soft red marl ...	6	0	47	0
8	Red marl	16	10	63	10
9	Red and blue marl, with veins of gypsum	7	0	70	10
10	Red and blue marl, with veins of gypsum	3	0	73	10
11	Red and blue marl with veins of gypsum	21	3	95	1
12	Red marl, with veins of gypsum	46	8	141	9
13	Red and blue marl, with veins of gypsum	15	3	157	0
14	Red and blue shale, with veins of gypsum	325	0	482	0
15	Blue shaly sandstone	2	0	484	0
16	Red sandstone, with thin beds of gypsum and shale ...	10	0	494	0
17	Sandstone, with thin beds of shale	11	0	505	0
18	Red sandstone ...	415	8	920	8
19	Red sandstone, with thin beds of marl	39	0	959	8
20	Red sandy marl ...	8	6	968	2
21	Red sandstone ...	29	0	997	2
22	Red sandy marl ...	4	2	1,001	4
23	Red sandstone, with small beds of marl	46	0	1,047	4
24	Red marl	8	6	1,055	10
25	Red sandstone, with beds of marl ...	34	6	1,090	4
26	Red marl	17	8	1,108	0
27	Red sandstone, with veins of marl ...	18	0	1,126	0
28	Red sandstone, with beds of marl ...	120	7	1,246	7
29	Red marl, with beds of red sandstone	21	11	1,268	6
30	Red sandstone, with beds of marl ...	14	6	1,283	0
31	Red marl, with sandstone	4	6	1,287	6
32	Red marl	43	0	1,330	6
33	Red sandy marl, with veins of gypsum	6	0	1,336	6
34	Red sandy marl, with blue spots and veins of gypsum	36	6	1,373	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
35	Red sandy marl, with thin veins of gypsum	78	0	1,451	0
36	Red sandy marl, with veins of gypsum and blue spots	9	6	1,460	6
37	Red sandy marl, with veins of gypsum	10	0	1,470	6
38	Red sandy marl, with veins of gypsum and blue spots	60	6	1,531	0
39	Hard white stone, anhydrite ...	11	6	1,542	6
40	Red sandy marl, with *salt* ...	21	0	1,563	6
41	Red marl, with *salt*	6	3	1,569	9
42	ROCK SALT ...	81	0	1,650	9
43	Hard white stone, with *salt* ...	1	6	1,652	3
44	Hard white stone...	1	6	1,653	9
45	Hard stone and a little *salt* - ...	18	0	1,671	9
46	Hard white stone, with a little *salt* in it	7	11½	1,679	8½

XXI.—*Diamond-boring (12-inch hole) on the Lackenby Foreshore Estate, by Messrs. Mather and Platt, 1889.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Clay and gravel ...	13	0	13	0
2	Hard red clay and a little gypsum...	11	8	24	8
3	Red marl and thin rock ...	62	4	87	0
4	Red marl and bed of blue marl ...	159	8	246	8
5	Bed of hard rock ...	8	4	255	0
6	Blue and red marl...	88	0	343	0
7	Dark red marl and blue stone ...	30	0	373	0
8	Hard blue stone ...	7	0	380	0
9	Red marl	217	0	597	0
10	Red sandstone ...	598	0	1,195	0
11	Red marl	77	0	1,272	0
12	Red marl and sandstone beds ...	371	0	1,643	0
13	Hard white rock ...	20	0	1,663	0
14	Honeycomb marl...	9	0	1,672	0
15	SALT and marl, mixed	13	0	1,685	0
16	ROCK SALT, clean	119	0	1,804	0
17	White rock ...	2	0	1,806	0

XXII.—*No. 1 Diamond-boring at Port Clarence, by Mr. John Vivian, for Messrs. C. Allhusen and Sons.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Peat and muddy sand	10	0	10	0
2	Dark muddy sand	6	0	16	0
3	Dark sand	4	0	20	0
4	Sand and gravel ...	4	0	24	0
5	Dark sandy clay ...	4	0	28	0
6	Sandy clay ...	17	0	45	0
7	Running sand ...	35	0	80	0
8	Sand and gravel ...	4	0	84	0
9	Hard bound gravel	3	0	87	0
10	Strong red pinnel ...	7	0	94	0
11	Grey sandy clay ...	1	0	95	0
12	Red pinnel ...	4	0	99	0
13	Red and blue shale	17	0	116	0
14	Red sandy shale, with gypsum ...	18	0	134	0
15	Red and grey sandy shale, with gypsum	3	6	137	6
16	Grey sandy shale, with gypsum ...	6	6	144	0
17	Red and grey sandy shale, with gypsum	29	0	173	0
18	Grey sandy shale, with gypsum ...	4	6	177	6
19	Red and grey sandy shale, with gypsum	3	0	180	6
20	Red shale	17	0	197	6
21	Red and grey sandy shale	12	3	209	9
22	Soft red sandstone	119	6	329	3
23	Red sandstone ...	193	9	523	0
24	Red shale	5	6	528	6
25	Red sandstone ...	33	0	561	6
26	Red shale, with beds of sandstone ..	5	0	566	6
27	Red sandstone ...	41	0	607	6
28	Strong red shale ...	1	6	609	0
29	Red sandstone ...	4	0	613	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
30	Strong red shale ...	5	0	618	0
31	Red sandstone ...	34	0	652	0
32	Strong red shale ...	1	0	653	0
33	Red sandstone ...	1	0	654	0
34	Strong red shale ...	11	0	665	0
35	Red shale, with beds of sandstone ...	8	0	673	0
36	Red sandstone ...	17	0	690	0
37	Red sandstone, with beds of shale ...	61	0	751	0
38	Strong red shale ...	8	6	759	6
39	Red sandstone ...	29	6	789	0
40	Red shale	9	6	798	6
41	Red sandstone and shale	19	6	818	0
42	Strong red shale ...	10	0	828	0
43	Strong red shale, with light blue spots	6	6	834	6
44	Red sandstone, with light blue spots	5	0	839	6
45	Red shaly sandstone	16	6	856	0
46	Red sandy shale ...	9	0	865	0
47	Red sandy shale, with light blue spots	17	0	882	0
48	Red sandstone, with red shale beds ...	22	0	904	0
49	Red shale, with veins of gypsum	18	0	922	0
50	Red shale, with beds of sandstone ...	46	0	968	0
51	Red shale, with small blue joints and veins of gypsum	60	6	1,028	6
52	Red sandstone with veins of gypsum	12	0	1,040	6
53	Red and grey shale and gypsum mixed	12	0	1,052	6
54	Gypsum	1	0	1,053	6
55	Hard grey stone, with thin veins of gypsum	14	0	1,067	6
56	Hard grey stone ...	10	0	1,077	6
57	Hard grey stone, with gypsum ...	6	6	1,084	0
58	Grey stone, with veins and spots of gypsum	9	0	1,093	0
59	Magnesian limestone and gypsum ...	4	0	1,097	0
60	Magnesian limestone	28	0	1,125	0
61	Magnesian limestone, with gypsum ...	3	0	1,128	0
62	Magnesian limestone	33	0	1,161	0
63	Anhydrite	5	0	1,166	0
64	White gypsum ...	13	6	1,179	6
65	White rock ...	11	0	1,190	6
66	Magnesian limestone	22	6	1,213	0
67	Magnesian limestone, with veins of gypsum ...	6	0	1,219	0
68	Magnesian limestone	11	0	1,230	0
69	Anhydrite	3	0	1,233	0
70	Dark grey limestone, with gypsum and black joints	7	0	1,240	0
71	Dark grey limestone	5	0	1,245	0
72	Anhydrite	1	0	1,246	0
73	Limestone, with gypsum	3	0	1,249	0
74	Dark grey limestone, with gypsum and black joints	5	0	1,254	0
75	Dark grey limestone	4	0	1,258	0
76	Magnesian limestone and gypsum	2	0	1,260	0

XXIII.—*No. 1 (or Eastern) Boring at Haverton Hill, for the South Durham Salt Company, Limited (now Salt Union, Limited).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Yellow clay ...	3	0	4	0
3	Blue clay	35	3	39	3
4	Brown sand ...	0	9	40	0
5	Tough brown pinnel	12	0	52	0
6	Blue pinnel ...	3	10	55	10
7	Brown sandy pinnel	2	8	58	6
8	Hard bound gravel, with pinnel ...	2	10	61	4
9	Gravel and pinnel mixed	1	5	62	9
10	Red sandstone ...	31	9	94	6
11	Grey sandstone ...	1	0	95	6
12	Red sandstone ...	35	6	131	0
13	Red marl	1	0	132	0
14	Red sandstone ...	45	0	177	0
15	Red and grey sandstone	10	0	187	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
16	Red sandstone ...	13	0	200	0
17	Red and grey sandstone	18	6	218	6
18	Red sandstone ...	21	0	239	6
19	Red marl	2	6	242	0
20	Red sandstone ...	28	6	270	6
21	Red sandstone, with marl joints ..	25	7	296	1
22	Red sandstone ..	25	7	321	8
23	Red marl	1	6	323	2
24	Red sandstone, very jointy	8	6	331	8
25	Red sandstone ...	37	0	368	8
26	Red marl	4	0	372	8
27	Red sandstone, jointy	40	5	413	1
28	Red marl	12	0	425	1
29	Red sandstone, with marl joints ...	11	6	436	7
30	Red sandstone ...	8	5	445	0
31	Red sandstone, with marl joints ...	21	9	466	9
32	Red sandstone ...	22	5	489	2
33	Red sandstone, with marl joints ...	11	0	500	2
34	Red marl	8	0	508	2
35	Red sandstone ...	33	5	541	7
36	Red marl	5	0	546	7
37	Red sandstone ...	19	8	566	3
38	Red sandy marl ...	22	4	588	7
39	Red marl	8	3	596	10
40	Sandstone	2	0	598	10
41	Sandy marl ...	3	9	602	7
42	Red sandy marl ...	27	4	629	11
43	Red sandstone ...	5	0	634	11
44	Red marl	14	8	649	7
45	Red marl, strong ...	2	0	651	7
46	Strong marl, with gypsum	8	3	659	10
47	Strong marl ...	14	8	674	6
48	Red sandy marl ...	22	10	697	4
49	Red marl, with long vein of gypsum...	9	8	707	0
50	Red sandy marl ...	9	1	716	1
51	Red marl, with gypsum joints ...	13	6	729	7
52	Red sandy marl .	3	0	732	7
53	Red marl, with veins of gypsum ...	4	4	736	11
54	Red marl	6	0	742	11
55	Red marl, with large veins of gypsum	24	6	767	5
56	Red sandy marl, with gypsum joints	22	11	790	4
57	Red marl, with gypsum	56	5	846	9
58	Anhydrite	9	6	856	3
59	Red marl, containing a little *salt*...	11	1	867	4
60	Dark red marl, containing *salt* ...	3	0	870	4
61	**SALT**	86	6	956	10
62	**SALT** and gypsum mixed	10	10	967	8
63	Gypsum, containing *salt*	1	0	968	8
64	Gypsum	5	0	973	8
65	**SALT**	8	10	982	6
66	**SALT** and gypsum	16	8	999	2
67	Anhydrite	7	2	1,006	4

XXIV.—*No. 4 (or Western) Boring at Haverton Hill, for the South Durham Salt Company, Limited (now Salt Union, Limited).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Yellow clay ...	4	0	5	0
3	Brown clay ...	10	0	15	0
4	Brown clay and cobbles	17	0	32	0
5	Brown sand and clay	3	1	35	1
6	Loamy sand ...	12	5	47	6
7	Brown pinnel ...	15	0	62	6
8	Yellow sandy clay	1	9	64	3
9	Brown pinnel ...	4	9	69	0
10	Red sandstone ...	160	6	229	6
11	Red marl	4	0	233	6
12	Red sandstone ...	79	0	312	6
13	Red marl	4	8	317	2
14	Red sandstone ...	34	0	351	2
15	Red marl	9	6	360	8
16	Red sandstone ...	79	10	440	6
17	Red marl	1	0	441	6
18	Red sandstone ...	70	6	512	0
19	Red sandy marl ...	64	6	576	6
20	Red marl	72	10	649	4
21	Red marl, with veins of gypsum ...	140	6	789	10
22	Anhydrite	6	0	795	10
23	*Salty* marl	14	0	809	10
24	Red *salty* marl ...	3	0	812	10
25	**ROCK SALT** ...	104	6	917	4
26	Gypsum	7	6	924	10

XXV.—*Diamond-boring at Westfield, Haverton Hill, by Mr. John Vivian, for Mr. George Dyson, May 30 to November 21, 1885. (Now Westfield, Durham, Salt Company, Limited).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Yellow clay	2	0	3	0
3	Brown clay	8	6	11	6
4	Sand	2	0	13	6
5	Hard red clay and cobbles	6	6	20	0
6	Sand	0	6	20	6
7	Tough brown pinnel	8	6	29	0
8	Sand	2	6	31	6
9	Red clay	1	3	32	9
10	Sand	11	3	44	0
11	Brown sandy clay	1	0	45	0
12	Brown pinnel	3	0	48	0
13	Tough brown pinnel	9	0	57	0
14	Rough sand and fine gravel	3	6	60	6
15	Bound gravel	0	6	61	0
16	Hard bound gravel	3	8	64	8
17	Red sandstone	8	8	73	4
18	Red sandstone	30	5	103	9
19	Red sandstone, with veins of spar	15	9	119	6
20	White sandstone	5	0	124	6
21	Red sandstone	69	11	194	5
22	Red sandstone	35	7	230	0
23	Soft red marl	8	0	238	0
24	Red sandstone	24	6	262	6
25	Red sandstone	54	0	316	6
26	Red marl	4	0	320	6
27	Red sandstone	11	6	332	0
28	Red sandstone	23	9	355	9
29	Sandy marl	8	0	363	9
30	Red marl	10	3	374	0
31	Red sandstone	20	0	394	0
32	Red sandstone	59	9	453	9
33	Red marl	3	0	456	9
34	Red sandstone	23	3	480	0
35	Red marl	8	6	488	6
36	Red sandstone	5	0	493	6
37	Red sandstone	15	6	509	0
38	Red marl	21	6	530	6
39	Sandy marl	8	6	539	0
40	Red marl	18	6	557	6
41	Sandy marl, with veins of gypsum	18	0	575	6
42	Red marl	10	0	585	6
43	Red marl, with veins of gypsum	25	0	610	6
44	Red marl	19	0	629	6
45	Red marl	8	0	637	6
46	Red marl, with veins of gypsum	10	6	648	0
47	Red marl, with veins of gypsum	73	6	721	6
48	Red marl, with veins of gypsum	52	6	774	0
49	Anhydrite	5	6	779	6
50	Red marl, rather *salty*	3	0	782	6
51	Red *salty* marl	11	0	793	6
52	Red marl, containing *salt*	2	6	796	0
53	**ROCK SALT**	15	8	811	8
54	**ROCK SALT**	0	9	812	5
55	**ROCK SALT**	24	6	836	11
56	**ROCK SALT**	53	10	890	9
57	**ROCK SALT,** mixed with gypsum	6	0	896	9
58	Gypsum and *salt*	0	6	897	3
59	Gypsum and *salt*	2	0	899	3
60	Gypsum, containing a little *salt*	8	11	908	2
61	Anhydrite	1	0	909	2

XXVI.—*Boring at Sandfield, Haverton Hill, 1886.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	6	1	6
2	Strong red clay	4	6	6	0
3	Brown sand	30	4	36	4
4	Dark sand	11	1	47	5
5	Brown clay	3	4	50	9
6	Brown pinnel and cobbles	19	7	70	4
7	Red sandstone	145	8	216	0
8	Red marl	2	0	218	0
9	Red sandstone	82	0	300	0
10	Red marl	3	0	303	0
11	Red sandstone	38	7	341	7
12	Red marl	10	5	352	0
13	Red sandstone	102	2	454	2
14	Red sandstone, with beds of marl	7	8	461	10
15	Red marl	4	0	465	10
16	Red sandy marl	2	0	467	10
17	Red sandstone	20	2	488	0
18	Red marl	20	4	508	4
19	Red sandstone	17	8	526	0
20	Red marl	15	6	541	6
21	Red sandy marl	7	9	549	3
22	Red sandstone	6	7	555	10
23	Red marl	29	3	585	1
24	Red marl, with gypsum joints	8	6	593	7
25	Red sandy marl	52	11	646	6

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
26	Strong red marl, with veins of gypsum	38	9	685	3
27	Red marl	1	0	686	3
28	Red marl, with veins of gypsum ...	84	3	770	6
29	Anhydrite	9	6	780	0
30	Red marl, *salty* ...	12	0	792	0
31	Decayed brown marl, containing *salt* ...	5	0	797	0
32	**ROCK SALT** ...	80	10	877	10
33	Anhydrite and *rock salt*	1	6	879	4
34	**ROCK SALT** ...	1	0	880	4
35	Anhydrite and *salt*	4	2	884	6
36	Anhydrite, containing a little *salt*	9	9	894	3
37	**ROCK SALT** ...	6	0	900	3
38	Anhydrite	0	9	901	0

XXVII.—*No. 1 Diamond-boring at Haverton Hill, for Messrs. C. Tennant and Partners, Limited (now United Alkali Company, Limited).*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	6	1	6
2	Red sandy soil ...	5	6	7	0
3	Stiff dark muddy clay	10	0	17	0
4	Stiff red clay ...	17	0	34	0
5	Red clay and cobbles	3	0	37	0
6	Dark sand	0	9	37	9
7	Brown sand ...	16	7	54	4
8	Brown sand, very fine	5	2	59	6
9	Brown sandy pinnel and gravel ...	4	6	64	0
10	Brown sandy clay and cobbles ...	7	0	71	0
11	Cobbly pinnel ...	9	0	80	0
12	Sand and gravel ...	3	3	83	3
13	Red sandstone ...	93	5	176	8
14	Grey sandstone ...	8	0	184	8
15	Red sandstone ...	164	7	349	3
16	Red marl	3	0	352	3
17	Red sandstone ...	66	8	418	11
18	Grey stone	3	6	422	5
19	Red marl	3	0	425	5
20	Red sandstone ...	37	0	462	5
21	Red marl	16	9	479	2
22	Red sandstone ...	73	3	552	5
23	Red sandy marl ...	9	3	561	8
24	Red sandstone ...	24	0	585	8
25	Red sandy marl ...	2	9	588	5
26	Red sandstone ...	2	0	590	5
27	Red marl	6	6	596	11
28	Red stone and beds of marl	18	9	615	8
29	Red marl	19	0	634	8
30	Red stone and beds of marl	12	10	647	6
31	Red stone	3	0	650	6
32	Red marl, with blue joints ...	18	0	668	6
33	Red sandstone ...	5	0	673	6
34	Red sandy marl ...	20	6	694	0
35	Red marl, with veins of gypsum ...	84	0	778	0
36	Red marl, with blue joints and veins of gypsum ...	74	0	852	0
37	Red marl, with gypsum	42	6	894	6
38	Red marl	0	9	895	3
39	Anhydrite	9	0	904	3
40	Red marl, with *salt*	1	0	905	3
41	Red marl, with veins of *salt* ...	23	4	928	7
42	**ROCK SALT** ...	72	11	1,001	6
43	Hard stone... ...	3	2	1,004	8
44	Hard stone, with *salt*	2	8	1,007	4
45	**ROCK SALT** and gypsum... ...	6	0	1,013	4
46	Hard blue stone ...	0	10	1,014	2

XXVIII.—*No. 8a Boring, by the American system, at Haverton Hill, for the United Alkali Company, Limited (Messrs. C. Allhusen & Sons), completed November 18, 1891.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Ordinary surface-soil, etc. ...	5	0	5	0
2	Blue clay	30	0	35	0
3	Sand and clay ...	15	0	50	0
4	Sand and gravel ...	15	0	65	0
5	Gravel	5	0	70	0
6	Soft sandstone ...	5	0	75	0
7	Red sandstone ...	325	0	400	0
8	Red marl	332	0	732	0
9	Anhydrite	9	0	741	0
10	Rotten marl, containing *salt* ...	25	0	766	0
11	**ROCK SALT** ...	42	0	808	0
12	Light grey limestone	93	0	901	0
13	Dark grey limestone	18	0	919	0
14	Light grey limestone	313	0	1,232	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
15	Dark grey limestone	42	0	1,274	0
16	Black and red shale	41	0	1,315	0
17	Sand and water, gas bubbles... ...	48	0	1,363	0
18	Black and red shale	6	0	1,369	0
19	Grey limestone ...	20	0	1,389	0
20	Shale	18	0	1,407	0
21	Sticky substance, like fireclay ...	17	0	1,424	0
22	Dark limestone ...	8	0	1,432	0
23	Sand	9	0	1,441	0
24	Sand and limestone	18	0	1,459	0
25	Sand	20	0	1,479	0
26	Shale and fireclay...	20	0	1,499	0
27	Fireclay	36	0	1,535	0
28	Shale	9	0	1,544	0
29	Grey limestone ..	35	0	1,579	0
30	Black shale ...	18	0	1,597	0
31	Sandstone	7	0	1,604	0
32	Sandstone and shale	11	0	1,615	0
33	Limestone and shale	8	0	1,623	0
34	Sandstone	30	0	1,653	0
35	Limestone	11	0	1,664	0
36	Light grey sandstone	9	0	1,673	0
37	Dark sandstone and shale	21	0	1,694	0
38	Shale	44	0	1,738	0
39	Black shale ...	16	0	1,754	0
40	Black shale ...	24	0	1,778	0
41	Limestone	16	0	1,794	0
42	Grey sandstone ..	19	0	1,813	0
43	Sandstone, mixed with shale ...	20	0	1,833	0
44	Fine sand, with water	16	0	1,849	0
45	Black shale and sand	13	0	1,862	0
46	Shale	53	0	1,915	0
47	Grey limestone ...	12	0	1,927	0
48	Grey limestone, with a little shale ...	12	0	1,939	0
49	Grey sandstone ...	5	0	1,944	0
50	Shale and a little sand	6	0	1,950	0
51	COAL and a little gas	2	0	1,952	0
52	Limestone	6	0	1,958	0
53	Sandstone	14	0	1,972	0
54	Sandy shale and a little gas* ...	2	0	1,974	0
55	Hard shale... ...	3	0	1,977	0
56	Hard black shale ...	9	0	1,986	0
57	Grey sandstone ...	2	0	1,988	0
58	Black shale ...	2	0	1,990	0
59	Grey micaceous sandstone	8	0	1,998	0
60	Black shale ...	11	0	2,009	0
61	Limestone	26	0	2,035	0
62	Grey micaceous sandstone	7	6	2,042	6
63	Grey micaceous sandstone, with veins of shale... ...	32	0	2,074	6
64	Hard black shale, with veins of sandstone ...	6	0	2,080	6
65	Micaceous sandstone	9	0	2,089	6
66	Hard shale... ...	3	0	2,092	6
67	Micaceous sandstone	8	0	2,100	6
68	Hard grey shale ...	3	6	2,104	0
69	Hard black shale ...	48	6	2,152	6
70	Dark sandy shale ..	3	6	2,156	0
71	In hard black shale	17	0	2,173	0

XXIX.—*Boring at Stone Marsh or Sweethill, near Haverton Hill, 1886.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Yellow clay ...	1	0	2	0
3	Red clay	16	6	18	6
4	Brown pinnel ..	24	6	43	0
5	Red sandy pinnel...	1	0	44	0
6	Blue and sandy clay	10	0	54	0
7	Red clay	8	0	62	0
8	Sand and gravel ...	1	0	63	0
9	Gravel	2	0	65	0
10	Gravel and cobbles	2	6	67	6
11	Sand and gravel ...	3	6	71	0
12	Sand	2	0	73	0
13	Gravel and cobbles	2	0	75	0
14	Bound gravel and pinnel	5	0	80	0
15	Pinnel and gravel...	4	6	84	6
16	Clayey sand ...	7	0	91	6
17	Pinnel and gravel...	2	6	94	0
18	Bound gravel ...	6	6	100	6
19	Fine gravel ...	4	3	104	9
20	Red sandstone ...	179	3	284	0
21	Red marl	2	9	286	9
22	Red sandstone ...	20	3	307	0
23	Sandy marl ...	6	0	313	0
24	Red marl	7	0	320	0
25	Red sandstone ...	78	0	398	0
26	Red sandy marl ...	21	0	419	0
27	Red marl	3	0	422	0
28	Red sandstone ...	31	6	453	6
29	Red marl	6	6	460	0
30	Red sandstone, with marl beds ...	15	3	475	3
31	Red marl, with red sandstone beds ...	11	6	486	9
32	Red marl, with blue joints	7	3	494	0

* Continued from this point by the diamond drill, August 25, 1891.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
33	Red sandstone, with marl beds ...	14	3	508	3
34	Red sandstone ...	4	0	512	3
35	Red marl	14	9	527	0
36	Red marl, with red sandstone ..	3	3	530	3
37	Red marl	18	6	548	9
38	Red marl, with blue joints	41	6	590	3
39	Red sandstone ...	2	0	592	3
40	Red marl, with blue joints	9	6	601	9
41	Red marl, with blue joints and veins of gypsum ...	62	3	664	0
42	Red marl	15	0	679	0
43	Red marl, with veins of gypsum ...	61	0	740	0
44	Red marl	8	6	748	6
45	Red marl, with veins of gypsum	7	6	756	0
46	Anhydrite	9	0	765	0
47	Decayed red' marl, containing *salt* ...	10	3	775	3
48	Red *salty* marl ...	1	9	777	0
49	Anhydrite	7	0	784	0
50	SALT and gypsum	9	0	793	0
51	Anhydrite	7	0	800	0
52	Anhydrite, with black joints ...	14	3	814	3
53	Anhydrite ...	7	6	821	9
54	Magnesian limestone	7	9	829	6
55	Magnesian limestone, with gypsum joints	12	6	842	0
•56	Magnesian limestone	26	9	868	9
57	Magnesian limestone, with gypsum veins	17	7	886	4
58	Hard blue stone, with veins of gypsum	5	8	892	0
59	Red and blue marl, with gypsum ...	1	8	893	8
60	Hard blue and red stone	0	8	894	4
61	Anhydrite	3	8	898	0
62	Red marl, with anhydrite and gypsum	2	10	900	·10
63	Anhydrite, with red marl and gypsum veins	15	11	916	9
64	Anhydrite and magnesian limestone	14	8	931	5
65	Magnesian limestone, with gypsum veins and blue shale joints	11	11	943	4
66	Anhydrite	3	4	946	8
67	Magnesian limestone, with gypsum veins	9	0	955	8
68	Anhydrite	4	0	959	8
69	Anhydrite, with spots of gypsum ...	9	1	968	9
70	Magnesian limestone, with gypsum veins	31	3	1,000	0

XXX.—*No. 1 Diamond-boring on the White House Estate, near Norton, by Mr. John Vivian, 1889.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Brown sandy clay	8	0	8	0
2	Blue clay	7	0	15	0
3	Red clay	10	0	25	0
4	Stiff brown clay ...	21	0	46	0
5	Muddy sand ...	2	0	48	0
6	Brown sandy clay	2	0	50	0
7	Grey pinnel, with stones	2	0	52	0
8	Stiff brown clay, with stones ...	2	0	54	0
9	Stiff brown clay ...	14	0	68	0
10	Sand	1	0	69	0
11	Sandy clay ...	1	0	70	0
12	Strong brown pinnel	7	0	77	0
13	Strong brown clay	1	0	78	0
14	Strong pinnel, with cobbles	6	0	84	0
15	Brown pinnel ...	1	0	85	0
16	Sand	0	6	85	6
17	Dark gravelly pinnel	2	0	87	6
18	Grey pinnel, with cobbles	2	0	89	6
19	Brown pinnel ...	2	10	92	4
20	Sandstone	0	4	92	8
21	Dark brown pinnel	13	4	106	0
22	Dark red pinnel, with sandstone cobbles	1	6	107	6
23	Grey pinnel ...	7	0	114	6
24	Dark red pinnel ...	0	6	115	0
25	Red sandstone ...	19	0	134	0
26	Red sandy marl ...	9	0	143	0
27	Red marl	1	7	144	7
28	Red sandstone ..	9	4	153	11
29	Red sandy marl ...	2	0	155	11
30	Red sandstone ...	4	2	160	1
31	Red marl	22	0	182	1
32	Red sandstone ...	7	8	189	9
33	Red marl	21	7	211	4
34	Red marl, with blue joints	13	8	225	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
35	Red marl	41	0	266	0
36	Red marl, with veins of gypsum	8	3	274	3
37	Red marl	10	0	284	3
38	Red marl, with veins of gypsum	12	5	296	8
39	Red marl	22	2	318	10
40	Red marl, with veins of gypsum	77	2	396	0
41	Anhydrite	10	0	406	0
42	Red marl, with veins of gypsum	17	2	423	2
43	Anhydrite	17	9	440	11
44	Gypsum	3	0	443	11
45	Magnesian limestone, with veins of gypsum	13	8	457	7
46	Magnesian limestone	55	4	512	11
47	Blue shale, with veins of gypsum	11	11	524	10
48	Dark limestone and gypsum	1	0	525	10
49	Blue shale and gypsum	3	0	528	10
50	Anhydrite	4	0	532	10
51	Red and blue shale, with veins of gypsum	5	0	537	10
52	Anhydrite	1	0	538	10
53	Red and blue shale	2	7	541	5
54	Anhydrite, limestone, and red shale mixed	2	9	544	2
55	Anhydrite, with brown shale joints	21	5	565	7
56	Anhydrite	10	0	575	7
57	Anhydrite, with black shale joints	2	5	578	0
58	Magnesian limestone	13	11	591	11
59	Anhydrite, with veins of gypsum	7	0	598	11
60	Anhydrite	14	3	613	2
61	Anhydrite, containing gypsum	15	10	629	0
62	Blue marl	8	0	637	0
63	Anhydrite, with gypsum	1	6	638	6
64	Red marl, with veins of gypsum	7	7	646	1
65	Anhydrite, with gypsum	2	0	648	1
66	Red marl, with gypsum	11	8	659	9
67	Red and blue marl, with gypsum	8	6	668	3
68	Anhydrite, containing spar	2	2	670	5
69	Magnesian limestone, containing spar	8	10	679	3
70	Red and blue marl	4	3	683	6
71	Red sandy gritstone	3	4	686	10
72	Red and blue marl	6	3	693	1
73	Magnesian limestone, broken	49	10	742	11
74	Grey gritstone	4	9	747	8
75	Grey sandstone	1	0	748	8
76	Magnesian limestone, broken	6	0	754	8
77	Limestone	6	0	760	8
78	Dark blue shale	5	2	765	10
79	Light grey sandstone	8	2	774	0
80	Dark sandy shale	6	0	780	0
81	Light grey sandstone	7	3	787	3
82	Dark sandy shale	9	9	797	0
83	Dark shale	16	5	813	5
84	White sandstone	4	0	817	5
85	Light grey sandstone	7	2	824	7
86	Coarse light grey sandstone	3	11	828	6
87	Dark shale	2	0	830	6
88	Black shale, with bands and balls of ironstone	23	7	854	1
89	Black shale, with balls of ironstone	8	3	862	4
90	Black shale	10	8	873	0
91	Black shale, with veins of gypsum	4	0	877	0
92	Dark grey limestone	3	7	880	7
93	Black shale	13	6	894	1
94	Grey limestone	5	11	900	0
95	Dark limestone	5	11	905	11
96	Dark limestone, very jointy	6	8	912	7
97	Dark limestone	3	0	915	7
98	Dark grey sandy shale	10	0	925	7
99	Black shale	16	9	942	4
100	Grey sandstone	3	0	945	4
101	Black shale	7	6	952	10
102	Grey sandstone	3	0	955	10
103	Black shale	8	0	963	10
104	Dark grey sandstone with black joints	0	6	964	4
105	Dark grey sandstone and black shale mixed	13	0	977	4
106	Coarse light grey sandstone	18	0	995	4
107	Dark grey sandy shale	2	8	998	0
108	Black shale, with iron nodules	3	4	1,001	4
109	Dark grey sandy shale	1	3	1,002	7
110	Black shale, with iron nodules	5	3	1,007	10
111	Dark grey sandy shale	3	0	1,010	10

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
112	Black shale, with dark limestone balls	16	0	1,026	10
113	Grey limestone ...	10	4	1,037	2
114	Black shale ...	1	1	1,038	3
115	Blue shale	5	8	1,043	11
116	Grey sandy shale ...	7	6	1,051	5
117	Dark grey sandy shale, with veins of spar	18	0	1,069	5
118	Dark grey sandy shale	9	0	1,078	5
119	Black shale ...	1	1	1,079	6

XXXI.—*Boring at Kirklevington, about 2 miles south and east from Yarm, for Lord Falkland, commenced in 1856, and continued during 1857 and 1858.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Reddish clay ...	27	0	27	0
2	Fine sand	7	0	34	0
3	Coarse sand ...	4	0	38	0
4	Fine sand	10	0	48	0
5	Reddish clay ...	51	0	99	0
6	Yellow sandstone ...	0	8	99	8
7	White sandstone, hard	0	9	100	5
8	Sand and gravel ...	4	0	104	5
9	White sandstone ...	1	6	105	11
10	Sand and gravel ...	3	3	109	2
11	Light bluish sandstone	119	10	229	0
12	White sandstone, extra hard ...	0	11	229	11
13	Light fireclay ...	1	5	231	4
14	Light fake* and fireclay	2	6	233	10
15	Red sandstone in bed	204	3	438	1
16	Red fake and blae	1	0	439	1
17	Red sandstone, hard	1	1	440	2
18	Red sandstone, softer	18	0	458	2
19	Red fake and blae	0	3	458	5
20	Red sandstone, extra hard	2	3	460	8
21	Red fake	7	3	467	11
22	Red sandstone, extra hard	2	6	470	5
23	Red fake	7	8	478	1
24	Red sandstone ...	4	0	482	1
25	Red fake	4	8	486	9
26	Red sandstone ...	2	1	488	10
27	Red fake and clay	2	8	491	6
28	Red sandstone ...	3	9	495	3
29	Red clay	0	7	495	10
30	Light red sandstone	1	9	497	7
31	Red sandstone, in bed	13	9	511	4
32	Red sandstone, in bed	3	0	514	4
33	Magnesian limestone	6	9	521	1
34	Red fake	3	0	524	1
35	Red fake and clay ...	8	8	532	9
36	Red fireclay ...	9	5	542	2
37	Magnesian limestone	6	0	548	2
38	Fake and clay ..	2	3	550	5
39	Magnesian limestone	1	6	551	11
40	Red fake and clay...	5	1	557	0
41	Red sandstone, hard	9	1	566	1
42	Red sandstone, in bed	4	9	570	10
43	Light red sandstone, hard	4	0	574	10
44	Red sandstone, very hard	1	4	576	2
45	Red sandstone and beds of fake ...	6	4½	582	6½
46	Red shale, with beds of red sandstone and threads of grey metal stone	16	2½	598	9
47	Grey pyritic sandstone	1	0	599	9
48	Red shale, with beds of hard red sandstone	24	3	624	0
49	Gypsum, called chalk or pipe-clay by the workmen	0	9	624	9
50	Red shaly sandstone	6	9	631	6
51	Red sandstone, with a shaly appearance	20	6	652	0
52	Red shaly-looking sandstone, containing some gypsum	20	0	672	0
53	Red sandstone, nearly uniform in appearance, with a great quantity of carbonate of lime and white masses of gypsum	17	6	689	6
54	Red sandstone, with a shaly appearance, with gypsum	6	0	695	6
55	Red shaly sandstone, with gypsum ...	14	6	710	0

* "Fake" is a Scotch term for shale, and "Blae" for white post or sandstone. This boring was made by Glasgow men, hence the use of these terms.

XXXII.—*No. 2 Boring from the bottom of a well at Eston Low Farm, and about 1,300 yards south of Eston Junction, for Messrs. Smith and Oakey.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Well	25	0	25	0
2	Shale	3	0	28	0
3	Soft dark grey shale, with water ...	2	6	30	6
4	Grey shale	16	6	47	0
5	Blue shale	4	0	51	0
6	Blue shale	18	0	69	0
7	Blue shale	7	0	76	0
8	Dark grey shale ...	20	0	96	0
9	Light shale... ...	14	8	110	8
10	Dark red shale ...	0	11	111	7
11	Red gypsum ...	2	0	113	7
12	Grey gypsum, mixed with white gypsum	1	8	115	3
13	Red gypsum, mixed with white gypsum	0	8	115	11
14	Grey gypsum, mixed with white gypsum	0	4	116	3
15	Red gypsum, mixed with white gypsum	1	0	117	3
16	White gypsum, a little mixed ...	1	0	118	3
17	Red gypsum, mixed with white gypsum	2	6	120	9
18	Solid white gypsum	0	6	121	3
19	Red gypsum, with much white gypsum	0	8	121	11
20	White gypsum ...	6	6	128	5

XXXIII.—*Boring on West Coatham Farm, Kirkleatham Estate, near Redcar, for Messrs. W. Bullen and Partners. (Long. 1° 5′ 28″ W., lat. 54° 36′ 31″ N.)*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Clay...	6	0	6	0
2	Blue shale, with dogger band ...	75	0	81	0
3	Nodular band ...	1	6	82	6
4	Blue shale	1	8	84	2
5	Nodular band ...	2	0	86	2
6	Blue shale	6	4	92	6
7	Nodular band ...	1	6	94	0
8	Blue shale	21	0	115	0
9	Bastard grey post...	5	0	120	0
10	Blue shale, with hard band ...	33	0	153	0
11	Dark shale, with sulphur and hard band	12	0	165	0
12	White and grey post, with water* ...	9	0	174	0
13	Red and white mottled, white and blue mottled post	12	0	186	0
14	Dark blue shale, with whin girdles	19	0	205	0
15	White shale† ...	18	0	223	0
16	Red marl, mixed with gypsum ...	86	0	309	0
17	Strong band ...	0	2	309	2
18	Red marl	23	0	332	2
19	Strong band ...	0	3	332	5
20	Strong red marl ...	7	0	339	5
21	White gypsum ...	1	4	340	9
22	Red marl	0	9	341	6

XXXIV.—*Boring on West Coatham Farm, Kirkleatham Estate, near Redcar, for Mr. Slate. (Long. 1° 5′ 28″ W., lat. 54° 36′ 45″ N.)*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	0	6	0	6
2	Clay...	6	0	6	6
3	Cashy partings, sulphurous... ...	0	4	6	10
4	Blue post and whin, with white metal partings and *salt* water	1	6	8	4
5	Blue, grey, and black metal, with slaty white girdles, without water...	10	0	18	4
6	Soft slaty metal ...	4	0	22	4
7	Hard grey post ...	0	4	22	8
8	Soft slaty metal ...	9	0	31	8
9	Hard grey post ...	0	8	32	4
10	Soft light grey post	12	0	44	4
11	Blue slaty metal ...	3	6	47	10
12	COAL	0	10	48	8
13	Dark blue metal, *coaly* and slaty	12	0	60	8
14	JET	0	1	60	9
15	White post and blue metal	3	0	63	9

* A feeder of salt water was met with in the stone which proved to be local, and was supposed to be the same salt water or brine spring found in sinking Slate's Pit.

† Bottom of the Lower Lias shale and top of the New Red Sandstone.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
16	Dark blue metal ...	6	0	69	9	33	White post and grey metal	2	0	115	0
17	Dark blue metal, *coaly*	2	6	72	3	34	Strong brown and white post and metal	1	3	116	3
18	Grey metal, with white and grey post	3	0	75	3	35	Strong white and grey post ...	0	10	117	1
19	Blue metal	3	6	78	9	36	Blue metal, with white post towards top ...	3	0	120	1
20	Hard band, *coaly* ...	0	4	79	1	37	Blue metal, with white post and mica	1	10	121	11
21	Fireclay	3	0	82	1	38	Blue metal and metal stone	3	6	125	5
22	Blue metal	4	8	86	9	39	Grey metal and hard girdles	3	3	128	8
23	Strong white post	0	6	87	3	40	Brown & grey metal, metal stone, white post and whin girdles	1	6	130	2
24	Dark metal stone and ironstone ...	0	2	87	5	41	Blue metal and metal stone	3	0	133	2
25	Strong post and ironstone	0	11	88	4	42	Blue metal... ...	2	6	135	8
26	Slaty metal, with *Coal*	1	2	89	6						
27	COAL	1	3	90	9						
28	Clay...	0	9	91	6						
29	Blue metal	10	6	102	0						
30	Dark blue slaty metal	6	6	108	6						
31	Grey metal, and white post ...	2	6	111	0						
32	Grey metal... ...	2	0	113	0						

XXXV.—*No. 1 Diamond-boring on the Elstob Estate, for the Earl of Eldon, commenced on May 29, 1873, and stopped on March 4, 1874.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Lime and sand ...	3	0	3	0	30	Hard limestone ...	4	0	382	0
2	Sand, clay, and gravel	31	0	34	0	31	Strong dark shale...	17	0	399	0
3	Quicksand	29	0	63	0	32	Sandstone and shale	11	0	410	0
4	Boulder clay and stones	18	0	81	0	33	Hard sandstone ...	1	0	411	0
5	Sand	2	0	83	0	34	Hard shale and spar	2	0	413	0
6	Quicksand	6	0	89	0	35	Strong dark shale ..	5	0	418	0
7	Boulder clay ...	2	0	91	0	36	Strong dark shale, full of spar ...	7	0	425	0
8	Sandy clay... ...	4	0	95	0	37	Strong shale ...	8	0	433	0
9	Quicksand	8	0	103	0	38	Soft shale and fireclay	2	0	435	0
10	Boulder clay ...	43	6	146	6	39	Hard red sandstone	6	0	441	0
11	Soft magnesian limestone	134	6	281	0	40	Soft dark shale and sandstone ...	12	0	453	0
12	Hard limestone :..	19	0	300	0	41	Soft dark shale ...	1	0	454	0
13	Sandstone and limestone	4	0	304	0	42	Strong sandstone ..	3	0	457	0
14	Grey limestone ...	5	0	309	0	43	Hard purple sandstone	7	0	464	0
15	Fireclay	2	0	311	0	44	Soft sandstone, with shale bands ...	54	0	518	0
16	Grey limestone ...	1	0	312	0	45	Hard blue limestone	44	0	562	0
17	Light blue limestone	3	0	315	0	46	Sandstone, with bands of shale...	102	0	664	0
18	Red shaly limestone	7	0	322	0	47	Dark shale and spar	42	0	706	0
19	Shaly limestone ...	1	0	323	0	48	Light blue limestone	16	0	722	0
20	Hard limestone ...	19	0	342	0	49	White sandstone ...	25	0	747	0
21	Red sandstone ...	5	0	347	0	50	Soft dark shale ...	2	0	749	0
22	Red sandstone and shale	5	0	352	0	51	COAL, soft ...	0	3	749	3
23	White sandstone ...	8	0	360	0	52	Sandstone, with bands of shale ..	139	9	889	0
24	Soft dark shale ...	6	0	366	0	53	Light blue limestone	1	0	890	0
25	Sandstone and spar	5	0	371	0	54	Hard limestone ...	2	10	892	10
26	Soft dark shale ..	2	4	373	4						
27	Sandstone and spar	2	8	376	0						
28	Soft dark shale ...	1	0	377	0						
29	Fireclay	1	0	378	0						

Report on Elstob Boring.

The result of the experiment by boring at Elstob, to a depth approaching 900 feet, is to establish—

	Ft.	In.
First, an unusual thickness of Pleistocene deposits (boulder clay) ...	146	6
Secondly, the absence of all Triassic (New Red) deposits	...	
Thirdly, a considerable thickness of Magnesian Limestone	195	6
Fourthly, a considerable thickness of Permian (red or purple sandstone and shale) strata	122	0
Making of this upper series	464	0
Then follows a quite different group of strata, consisting of white and grey sandstones, grey and dark shales, and blue or blueish limestones, altogether at the date reported	428	10

In this series, which in a large sense is Carboniferous, three limestone beds occur, at intervals, from the top to No. 2, 54 feet; between No. 1 and No. 2, 144 feet; between No. 2 and No. 3, 167 feet; and below the second is a bed of coal enclosed in shale.

Surface.	Thickness. Ft.	In.
Pleistocene—		
Boulder clay	146	6
Permian—		
Magnesian Limestone	195	6
Red (purple) sandstone and shale	122	0
Carboniferous System below Millstone Grit (Yoredale Rocks)—		
White sandstone and shale ...	54	0
I. Blue limestone	44	0
Grey sandstone and shale ...	144	0
II. Blue limestone	16	0
Sandstone	25	0
Shale enclosing coal	4	0
Sandstone and shale	138	0
III. Blue limestone	not penetrated.	

FIG. 1.

This coal is said to be about 3 inches thick, and to be enclosed in shale about 3 feet 9 inches thick.

On considering Fig. 1 with attention, and examining the specimens of limestone from the three beds named, I arrive at the conclusion that the whole series of strata, penetrated to about 430 feet below the Permian (red and purple) sandstones and shales, belong to the Yoredale Rocks (upper part of the Mountain Limestone

series). The composition of the limestones, taken by themselves, would be quite enough to prove their affinity to some part of the Mountain Limestone series; and the succession of the beds, well considered in relation to the well-known sections in the mining dales lying to the westward (Weardale, Tynedale, Teesdale, etc.), leads to the probability that they belong to the Yoredale series, above the thick Scar limestones.

Adopting this conclusion as positive, I have to advise, in this first report, that the boring operations be discontinued at Elstob. By continuing the process, similar strata, and among them thin coal-seams would be found; but in this part of the Carboniferous range the limestone seams, as they may be termed, have no practical value, though farther to the north they are worked to profit.

What is already proved is of great importance in regard to any further steps which may be advisable, on which I shall be prepared to report after seeing selections from the other cores brought up in the boring, and considering the plans and other means of judging which you will be able to supply.

JOHN PHILLIPS,
Oxford.

April 4, 1874.

To John Johnson, Esq.,
Newcastle-upon-Tyne.

XXXVI.—*No. 2 Diamond-boring on the White House Estate, near Norton.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	1	0	1	0
2	Red sandy clay ...	4	0	5	0
3	Blue clay	15	2	20	2
4	Sand	1	4	21	6
5	Sand and gravel ...	1	6	23	0
6	Sand	5	1	28	1
7	Red clay	15	5	43	6
8	Dark brown sandy clay	30	3	73	9
9	Soft brown clay, mixed with sand	4	0	77	9
10	Brown pinnel ...	16	1	93	10
11	Red loamy sand ...	4	0	97	10
12	Brown pinnel ...	5	10	103	8
13	Grey sandstone ...	0	3	103	11
14	Brown pinnel ...	10	11	114	10
15	Grey loamy sand ...	2	0	116	10
16	Dark brown pinnel	2	11	119	9
17	Dark brown pinnel and cobbles ...	14	9	134	6
18	Red sandstone ...	24	8	159	2
19	Red marl	1	0	160	2
20	Red sandstone ...	23	10	184	0
21	Red marl	14	7	198	7
22	Red sandstone ...	9	2	207	9
23	Red marl	7	0	214	9
24	Red sandstone ...	3	6	218	3
25	Red sandy marl ...	40	0	258	3
26	Red sandstone ...	5	6	263	9
27	Red sandy marl ...	6	6	270	3
28	Red marly sandstone	21	3	291	6
29	Red marl, with gypsum and blue joints	1	7	293	1
30	Red marl, with blue joints and gypsum	6	0	299	1
31	Red marl, with veins of gypsum	13	8	312	9
32	Red marl, with blue joints and gypsum	11	0	323	9
33	Red marl, with veins of gypsum	49	5	373	2
34	Red marl, with blue joints	11	0	384	2
35	Red marl, with blue spots	17	1	401	3
36	Red sandy marl ...	10	7	411	10
37	Red marl, with veins of gypsum	6	0	417	10
38	Anhydrite	6	3	424	1
39	Red marl, with blue spots and gypsum	3	0	427	1
40	Red marl, with gypsum (compact)...	16	8	443	9
41	Anhydrite	20	6	464	3
42	Magnesian limestone	55	9	520	0

APPENDIX B.—ABSTRACTS OF SECTIONS OF BOREHOLES AND BRINE-WELLS IN CLEVELAND AND SOUTH DURHAM.

Number of Borehole on Plates LIV. and LV.	Situation of Borehole or Brine-well.	Thickness of Surface Deposits.	Upper Gypseous Marls, etc.		Red Sandstones and Marls.		Lower Gypseous Marls.		Saliferous Beds, Anhydrite, and Salt.		Magnesian Limestone and Lower Red Sandstone.		Carboniferous Measures.		Thickness of Salt.			Depth to Bottom of Salt.
			Thickness	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Pure.	Mixed.	Total.	
		Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft In.	Ft. In.
I.	Warren Cement Works, Hartlepool* ..	97 0	..	..	..	..	..	..	267 0	364 0	38 0	402 0	..	..	..	..	..	..
II.	Cellulose Works, West Hartlepool* ..	53 0	..	..	..	..	..	..	..	..	184 0	237 0	..	..	..	..	..	..
III.	Cement Works, West Hartlepool*	30 0	..	..	355 0	385 0	220 6	605 6	108 10	714 4	55 8	770 0	..	..	..	..	..	..
IV.	Seaton Carew*	33 0	..	..	256 0	289 0	194 5	483 5	38 7	522 0	888 0	1,410 0	404 6	1,814 6	..	..	..	..
V.	Oughton	119 0	..	..	405 5	524 5	..	..	..	..	..	..	..	..	..	..	..	..
VI.	Hartlepool Salt and Brine Co., Limited—																	
	Marsh House, Greatham, No. *a** ..	71 11	..	..	587 6	659 5	203 7	863 0	109 9	972 9	..	..	..	..	68 6	14 3	82 9	971 9
	" " " *b** ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	963 0
	" " " *c** ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	963 0
	" " " *d** ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	981 0
	" " " *e*† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	965 0
	" " " *f*† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	984 0
	" " " *g*† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	985 0
	" " " *h*† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	1,003 0
	" " " *i*† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	1,004 0
	United Alkali Co., Limited—																	
VII.	Cowpon Marsh No. 1*	87 0	..	..	694 0	781 0	279 6	1,060 0	154 0	1,214 0	..	..	..	..	112 9	4 0	116 9	1,207 9
VIII.	" " 2*	77 9	..	..	755 3	833 0	223 0	1,056 0	156 0	1,212 0	..	..	..	..	115 4	..	115 4	1,202 10
IX.	" " 3*	75 0	..	..	757 0	832 0	226 0	1,058 6	147 0	1,205 0	..	..	..	..	101 6	12 0	113 6	1,203 0
X.	" " 4*	78 8	..	..	761 10	840 6	220 6	1,061 0	153 0	1,214 0	..	..	..	..	90 6	28 8	119 2	1,209 0
	" " 5*	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	103 0	1,193 0
	" " 6*	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	99 6	1,206 6
	" " 7*	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	114 0	1,204 0
	" " 3'†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	?
	" " 3''†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	?
	" " 5'†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	?
	" " 8†	?	..	..	?	..	?	..	?	1,223 0	..	..	..	..	?	?	102 0	1,198 0
	" " 9†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	34 0	1,124 0
	" " 10†	?	..	..		..	?	..	?	..	..	..	..	..	?	?	100 0	1,190 0

* Diamond-boring. † American boring.

APPENDIX B.—ABSTRACTS OF SECTIONS OF BOREHOLES AND BRINE-WELLS IN CLEVELAND AND SOUTH DURHAM.—*Continued.*

Number of Borehole on Plates LIV. and LV.	Situation of Borehole or Brine-well.	Thickness of Surface Deposits.	Upper Gypseous Marls, etc.		Red Sandstones and Marls.		Lower Gypseous Marls.		Saliferous Beds, Anhydrite, and Salt.		Magnesian Limestone and Lower Red Sandstone.		Carboniferous Measures.		Thickness of Salt.			Depth to Bottom of Salt.
			Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Pure.	Mixed.	Total.	
		Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
	Salt Union, Limited—																	
XI.	Saltholme, No. 1 Clarence*	96 0	..	..	694 0	790 0	214 0	1,004 0	116 0	1,120 0	..	..	..	..	65 0	12 0	77 0	1,120 0
	" " 2* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	86 0	1,142 0
XII.	" " 3* "	77 0	..	..	846 0	923 0	179 0	1,102 0	159 0	1,261 0	94 0	1,355 0	..	..	64 5	35 0	99 5	1,236 0
	" " 4* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	76 0	1,232 0
	" " 5* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	82 0	1,218 0
	" " 6* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	84 0	1,205 0
	" " 7† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	85 0	997 0
	" " 8† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	84 0	986 0
	" " 9† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	70 0	1,180 0
	" " 10† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	71 0	1,172 0
	Bell Brothers, Limited—																	
XIII.	Port Clarence No. 1	92 0	..	..	837 0	929 0	152 0	1,081 0	140 8	1,221 8	..	..	..	..	88 0	11 8	99 8	1,211 8
	" " 2	92 0	..	..	850 0	942 0	134 0	1,076 0	148 0	1,224 0	..	..	..	..	80 0	6 0	86 0	1,224 0
XIV.	" " 3	89 0	..	..	886 0	975 0	190 0	1,165 0	135 0	1,301 0	..	..	..	..	93 0	3 0	96 0	1,291 0
	" " 4	104 0	..	..	871 0	975 0	199 0	1,174 0	131 0	1,305 0	..	..	..	..	88 0	19 0	107 0	1,302 0
XV.	" " 5	138 0	..	..	826 0	964 0	159 0	1,123 0	142 0	1,265 0	..	..	..	..	102 0	5 0	107 0	1,263 0
	" " 6	114 0	..	..	808 0	922 0	200 0	1,122 0	139 0	1,261 0	..	..	..	..	105 0	5 0	107 0	1,259 0
	Cleveland Salt Co., Limited—																	
XVI.	Middlesbro'	70 0	86 0	156 0	902 6	1,058 6	132 8	1,191 2	114 10	1,306 0	7 4	1,313 4	..	..	100 0	..	100 0	1,306 0
XVII.	" No. 1*	68 0	86 0	154 0	893 6	1,047 6	144 6	1,192 0	108 0	1,300 0	..	..	..	..	66 0	10 3	76 3	1,296 3
	" " 2†	70 0	90 0	160 0	988 0	1,148 0	34 0	1,182 0	118 0	1,300 0	..	..	..	..	85 0	..	85 0	1,295 0
	Owners of the Middlesbro' Estate, Ld.—																	
XVIII.	North Ormesby No. 1*	34 0	242 6	276 6	859 6	1,136 0	182 9	1,318 9	121 3	1,440 0	..	..	..	..	89 1	6 0	95 1	1,436 0
	" " 2†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
	" " 3†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
	" " 4†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
	" " 5†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
XIX.	Imperial Iron Works*	66 6	149 10	216 4	1,117 2	1,333 6	203 3	1,536 9	155 3	1,692 0	..	..	..	..	48 0	..	48 0	1,636 0
	Cleveland Salt Co., Limited—																	
XX.	South Bank, Eston No. 1*	41 0	453 0	494 0	836 6	1,330 6	200 6	1,531 0	148 8½	1,679 8½	..	..	..	..	81 0	1 6	82 6	1,652 3
	" " " 2†	18 0	502 0	520 0	800 0	1,320 0	217 0	1,537 0	123 0	1,660 0	..	..	..	..	72 0	15 0	87 0	1,655 0
XXI.	Lackenby*	24 8	572 4	597 0	846 0	1,443 0	200 0	1,643 0	163 0	1,806 0	..	..	..	..	119 0	13 0	132 0	1,804 0
XXII.	Port Clarence No. 1*	99 0	110 9	209 9	694 3	904 0	149 6	1,053 6	39 6	1,093 0	167 0	1,260 0	..	..	..	..	..	..
	" " 2* ‖	?	?	..	?	498 0	..	..	..	..	..	..	..	..	..	..	..	..

* Diamond-boring. † American boring.
‡ Sections and depths of salt are similar to those recorded for Boring XVIII., No. 1. ‖ Discontinued.

APPENDIX B.—ABSTRACTS OF SECTIONS OF BOREHOLES AND BRINE-WELLS IN CLEVELAND AND SOUTH DURHAM.

Number of Borehole on Plates LIV. and LV.	Situation of Borehole or Brine-well.	Thickness of Surface Deposits.	Upper Gypseous Marls, etc.		Red Sandstones and Marls.		Lower Gypseous Marls.		Saliferous Beds, Anhydrite, and Salt.		Magnesian Limestone and Lower Red Sandstone.		Carboniferous Measures.		Thickness of Salt.			Depth to Bottom of Salt.
			Thickness	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Pure.	Mixed.	Total.	
		Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
I.	Warren Cement Works, Hartlepool* ..	97 0	..	..	..	..	..	..	267 0	364 0	38 0	402 0	..	..	..	..	..	..
II.	Cellulose Works, West Hartlepool* ..	53 0	..	..	..	..	..	..	..	..	184 0	237 0	..	..	..	..	..	..
III.	Cement Works, West Hartlepool*	30 0	..	..	355 0	385 0	220 6	605 6	108 10	714 4	55 8	770 0	..	..	..	..	..	..
IV.	Seaton Carew*	33 0	..	..	256 0	289 0	194 5	483 5	38 7	522 0	888 0	1,410 0	404 6	1,814 6	..	..	..	..
V.	Oughton	119 0	..	..	405 5	524 5	..	..	..	..	..	..	..	..	..	..	..	..
VI.	Hartlepool Salt and Brine Co., Limited—																	
	Marsh House, Greatham, No. a* ..	71 11	..	..	587 6	659 5	203 7	863 0	109 9	972 9	..	..	..	..	68 6	14 3	82 9	971 9
	" " " b* ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	963 0
	" " " c* ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	963 0
	" " " d* ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	981 0
	" " " e† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	965 0
	" " " f† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	984 0
	" " " g† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	985 0
	" " " h† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	1,003 0
	" " " i† ..	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	1,004 0
	United Alkali Co., Limited—																	
VII.	Cowpon Marsh No. 1*	87 0	..	..	694 0	781 0	279 6	1,060 0	154 0	1,214 0	..	..	..	..	112 9	4 0	116 9	1,207 9
VIII.	" " 2*	77 9	..	..	755 3	833 0	223 0	1,056 0	156 0	1,212 0	..	..	..	..	115 4	..	115 4	1,202 10
IX.	" " 3*	75 0	..	..	757 0	832 0	226 0	1,058 8	147 0	1,205 0	..	..	..	..	101 6	12 0	113 6	1,203 0
X.	" " 4*	78 8	..	..	761 10	840 6	220 6	1,061 0	153 0	1,214 0	..	..	..	..	90 6	28 8	119 2	1,209 0
	" " 5*	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	103 0	1,193 0
	" " 6*	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	99 6	1,206 6
	" " 7*	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	114 0	1,204 0
	" " 3'†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	?
	" " 3''†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	?
	" " 5'†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	?	?
	" " 8†	?	..	..	?	..	?	..	?	1,223 0	..	..	..	..	?	?	102 0	1,198 0
	" " 9†	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	34 0	1,124 0
	" " 10†	?	..	..		..	?	..	?	..	..	..	..	..	?	?	100 0	1,190 0

* Diamond-boring. † American boring.

APPENDIX B.—ABSTRACTS OF SECTIONS OF BOREHOLES AND BRINE-WELLS IN CLEVELAND AND SOUTH DURHAM.—*Continued.*

Number of Borehole on Plates LIV. and LV.	Situation of Borehole or Brine-well.	Thickness of Surface Deposits.	Upper Gypseous Marls, etc.		Red Sandstones and Marls.		Lower Gypseous Marls.		Saliferous Beds, Anhydrite, and Salt.		Magnesian Limestone and Lower Red Sandstone.		Carboniferous Measures.		Thickness of Salt.			Depth to Bottom of Salt.
			Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Pure.	Mixed.	Total.	
		Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
	Salt Union, Limited—																	
XI.	Saltholme, No. 1 Clarence*	96 0	..	..	694 0	790 0	214 0	1,004 0	116 0	1,120 0	..	..	..	..	65 0	12 0	77 0	1,120 0
	" " 2* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	86 0	1,142 0
XII.	" " 3* "	77 0	..	..	846 0	923 0	179 0	1,102 0	159 0	1,261 0	94 0	1,355 0	..	..	64 5	35 0	99 5	1,226 0
	" " 4* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	76 0	1,232 0
	" " 5* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	82 0	1,218 0
	" " 6* "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	84 0	1,205 0
	" " 7† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	85 0	997 0
	" " 8† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	84 0	986 0
	" " 9† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	70 0	1,180 0
	" " 10† "	?	..	..	?	..	?	..	?	..	..	..	..	..	?	?	71 0	1,172 0
	Bell Brothers, Limited—																	
XIII.	Port Clarence No. 1	92 0	..	..	837 0	929 0	152 0	1,081 0	140 8	1,221 8	..	..	..	..	88 0	11 8	99 8	1,211 8
	" " 2	92 0	..	..	850 0	942 0	134 0	1,076 0	148 0	1,224 0	..	..	..	..	80 0	6 0	86 0	1,224 0
XIV.	" " 3	89 0	..	..	886 0	975 0	190 0	1,165 0	136 0	1,301 0	..	..	..	..	93 0	3 0	96 0	1,291 0
	" " 4	104 0	..	..	871 0	975 0	199 0	1,174 0	131 0	1,305 0	..	..	..	..	88 0	19 0	107 0	1,302 0
XV.	" " 5	138 0	..	..	826 0	964 0	159 0	1,123 0	142 0	1,265 0	..	..	..	..	102 0	5 0	107 0	1,263 0
	" " 6	114 0	..	..	808 0	922 0	200 0	1,122 0	139 0	1,261 0	..	..	..	..	105 0	5 0	107 0	1,259 0
	Cleveland Salt Co., Limited—																	
XVI.	Middlesbro'	70 0	86 0	156 0	902 6	1,058 6	132 8	1,191 2	114 10	1,306 0	7 4	1,313 4	..	..	100 0	..	100 0	1,306 0
XVII.	" No. 1*	68 0	86 0	154 0	893 6	1,047 6	144 6	1,192 0	108 0	1,300 0	..	..	..	..	66 0	10 3	76 3	1,296 3
	" " 2†	70 0	90 0	160 0	988 0	1,148 0	34 0	1,182 0	118 0	1,300 0	..	..	..	..	85 0	..	85 0	1,295 0
	Owners of the Middlesbro' Estate, Ld.—																	
XVIII.	North Ormesby No. 1*	34 0	242 6	276 6	859 6	1,136 0	182 9	1,318 9	121 3	1,440 0	..	..	..	..	89 1	6 0	95 1	1,436 0
	" " 2†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
	" " 3†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
	" " 4†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
	" " 5†	?	?	..	?	..	?	..	?	..	..	..	..	..	?	?	?	‡
XIX.	Imperial Iron Works*	66 6	149 10	216 4	1,117 2	1,333 6	203 3	1,536 9	155 3	1,692 0	..	..	..	..	48 0	..	48 0	1,636 0
	Cleveland Salt Co., Limited—																	
XX.	South Bank, Eston No. 1*	41 0	453 0	494 0	836 6	1,330 6	200 6	1,531 0	148 8½	1,679 8½	..	..	..	..	81 0	1 6	82 6	1,652 3
	" " " 2†	18 0	502 0	520 0	800 0	1,320 0	217 0	1,537 0	123 0	1,660 0	..	..	..	..	72 0	15 0	87 0	1,655 0
XXI.	Lackenby*	24 8	572 4	597 0	846 0	1,443 0	200 0	1,643 0	163 0	1,806 0	..	..	..	..	119 0	13 0	132 0	1,804 0
XXII.	Port Clarence No. 1*	99 0	110 9	209 9	694 3	904 0	149 6	1,053 6	39 6	1,093 0	167 0	1,260 0	..	..	..	..	..	..
	" " 2* ‖	?	?	..	?	498 0	..	..	..	..	..	..	..	..	..	..	..	..

* Diamond-boring. † American boring.

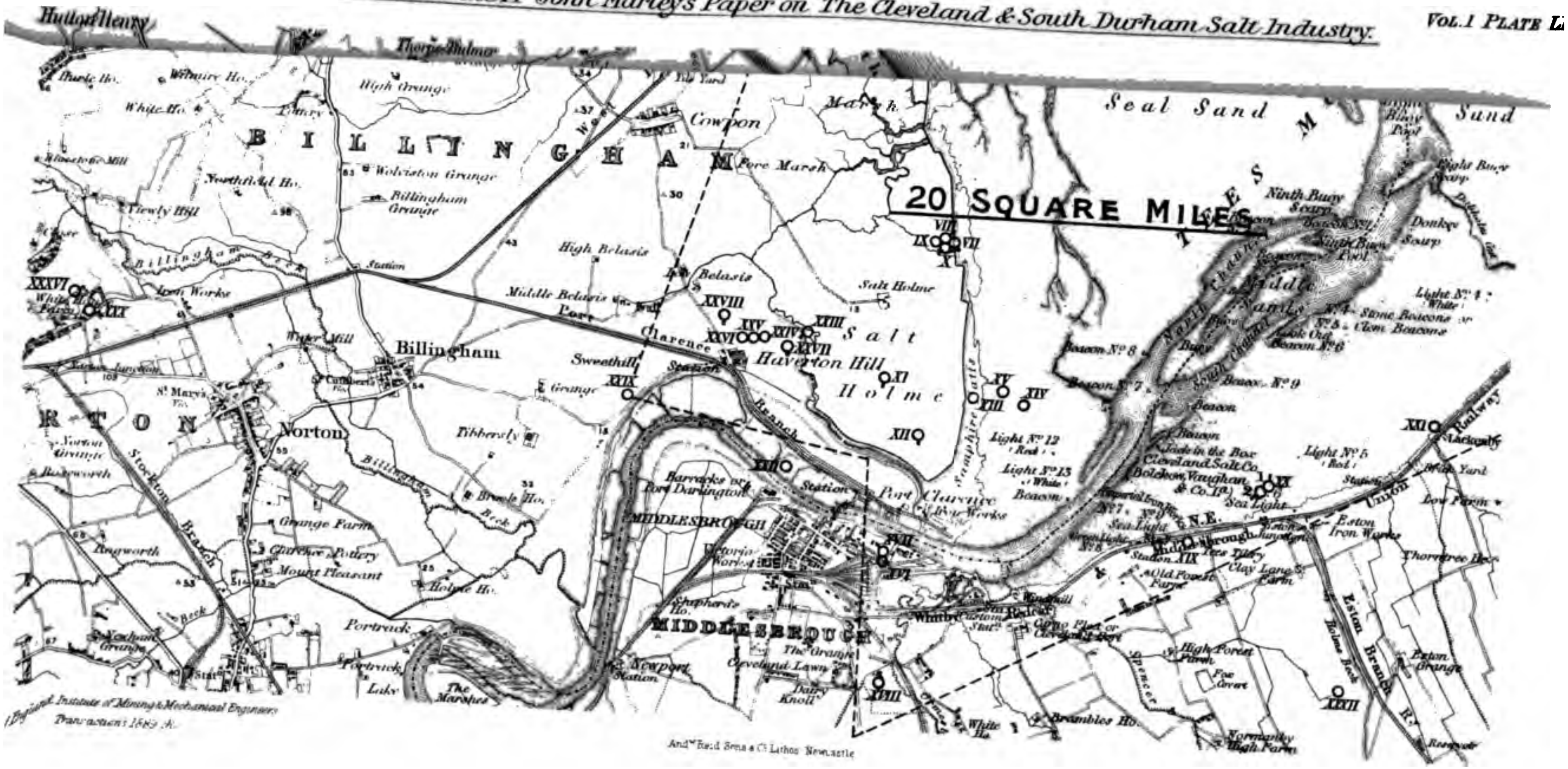
‡ Sections and depths of salt are similar to those recorded for Boring XVIII., No. 1. ‖ Discontinued.

APPENDIX B.—ABSTRACTS OF SECTIONS OF BOREHOLES AND BRINE-WELLS IN CLEVELAND AND SOUTH DURHAM.—*Continued.*

Number of Borehole on Plates LIV. and LV.	Situation of Borehole or Brine-well.	Thickness of Surface Deposits.	Upper Gypseous Marls, etc.		Red Sandstones and Marls.		Lower Gypseous Marls.		Saliferous Beds, Anhydrite, and Salts.		Magnesian Limestone and Lower Red Sandstone.		Carboniferous Measures.		Thickness of Salt.			Depth to Bottom of Salt.
			Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Pure.	Mixed.	Total.	
		Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
	Salt Union, Limited—																	
XXIII.	Haverton Hill (South Durham Salt Co., Limited) No. 1	62 9	..	..	588 10	651 7	195 2	846 9	159 7	1,006 4	..	..	..	..	95 4	33 6	128 10	999 2
	" " " " 2	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	98 0	996 0
	" " " " 3	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	91 0	969 0
XXIV.	" " " " 4	69 0	..	..	580 4	649 4	140 6	789 10	135 0	924 10	..	..	..	..	104 6	..	104 6	917 4
	" " " " 5	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	104 0	902 0
	" " " " 6	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	80 0	880 0
	" " " " 7	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	102 0	916 0
	" " " " 8	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	107 0	924 0
	" " " " 9	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	100 0	978 0
XXV.	Westfield Salt Co., Ld., Haverton Hill* ..	64 8	..	..	492 10	557 6	216 6	774 0	135 2	909 2	..	..	..	..	94 9	8 6	103 3	899 3
XXVI.	Sandfield, Haverton Hill	70 4	..	..	514 9	585 1	185 5	770 6	130 6	901 0	..	..	..	..	87 10	15 5	103 3	900 3
	United Alkali Co., Limited—																	
XXVII.	Haverton Hill (C. Tennant & Prs.) No. 1*	83 3	..	..	610 9	694 0	201 3	895 3	118 11	1,014 2	..	..	..	..	72 11	11 10	84 9	1,013 4
	" " " 2*	?	..	..	?	..	?	897 0	113 1	1,010 1	..	..	..	..	83 9	5 4	89 1	1,009 5
	" " " 3†	?	..	..	?	..	?	886 0	112 0	1,008 0	..	..	..	..	76 0	..	76 0	1,002 0
	" " " 4†	?	..	..	?	..	?	901 0	111 0	1,012 0	..	..	..	..	83 0	..	83 0	1,009 0
	" " " 5†	?	..	..	?	..	?	948 0	77 0	1,025 0	..	..	..	..	33 0	10 0	43 0	1,023 0
	" " " 6†	?	..	..	?	..	?	940 0	104 0	1,044 0	..	..	..	..	40 0	10 0	50 0	1,024 0
	" " " 7†	?	..	..	?	..	?	922 0	102 0	1,024 0	..	..	..	..	79 0	..	79 0	1,021 0
	" " " 8†	?	..	..	?	..	?	934 0	90 0	1,024 0	..	..	..	..	50 0	3 0	53 0	1,017 0
XXVIII	Haverton Hill (C. Allhusen & Sons) No. 8a†	70 0	..	..	480 0	550 0	182 0	732 0	76 0	808 0	671 0	1,479 0	694 0	2,173 0	42 0	..	42 0	808 0
	" " " 11†	?	..	..	?	..	?	..	?	..	..	..	..	..	34 0	..	34 0	810 0
	" " " 12†	?	..	..	?	..	?	..	?	..	..	..	..	..	40 0	..	40 0	?
	" " " A†	?	..	..	?	..	?	..	?	..	..	..	..	..	..	9 0	9 0	?
XXIX.	Stonemarsh*	104 9	..	..	497 0	601 9	154 3	756 0	65 9	821 9	178 3	1,000 0	..	..	..	9 0	9 0	793 0
XXX.	White House No. 1*	115 0	..	..	151 0	266 0	130 0	396 0	47 11	443 11	316 9	760 8	318 10	1,079 6	..	..	..	..
XXXI.	Kirklevington	109 2	600 10	710 0	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXII.	Eston, Low Farm	25 0	103 5	128 5	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXIII.	West Coatham	6 0	335 6	341 6	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXIV.	Do.	6 6	129 2	135 8	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXV.	Elstob	146 6	..	..	..	..	..	..	..	..	317 6	464 0	428 10	892 10	..	..	..	..
XXXVI.	White House No. 2	134 6	..	..	157 0	291 6	126 4	417 10	46 5	464 3	55 9	520 0	..	..	..	..	..	..

* Diamond-boring. † American boring.

To illustrate Mr John Marley's Paper on "The Cleveland & South Durham Salt Industry."



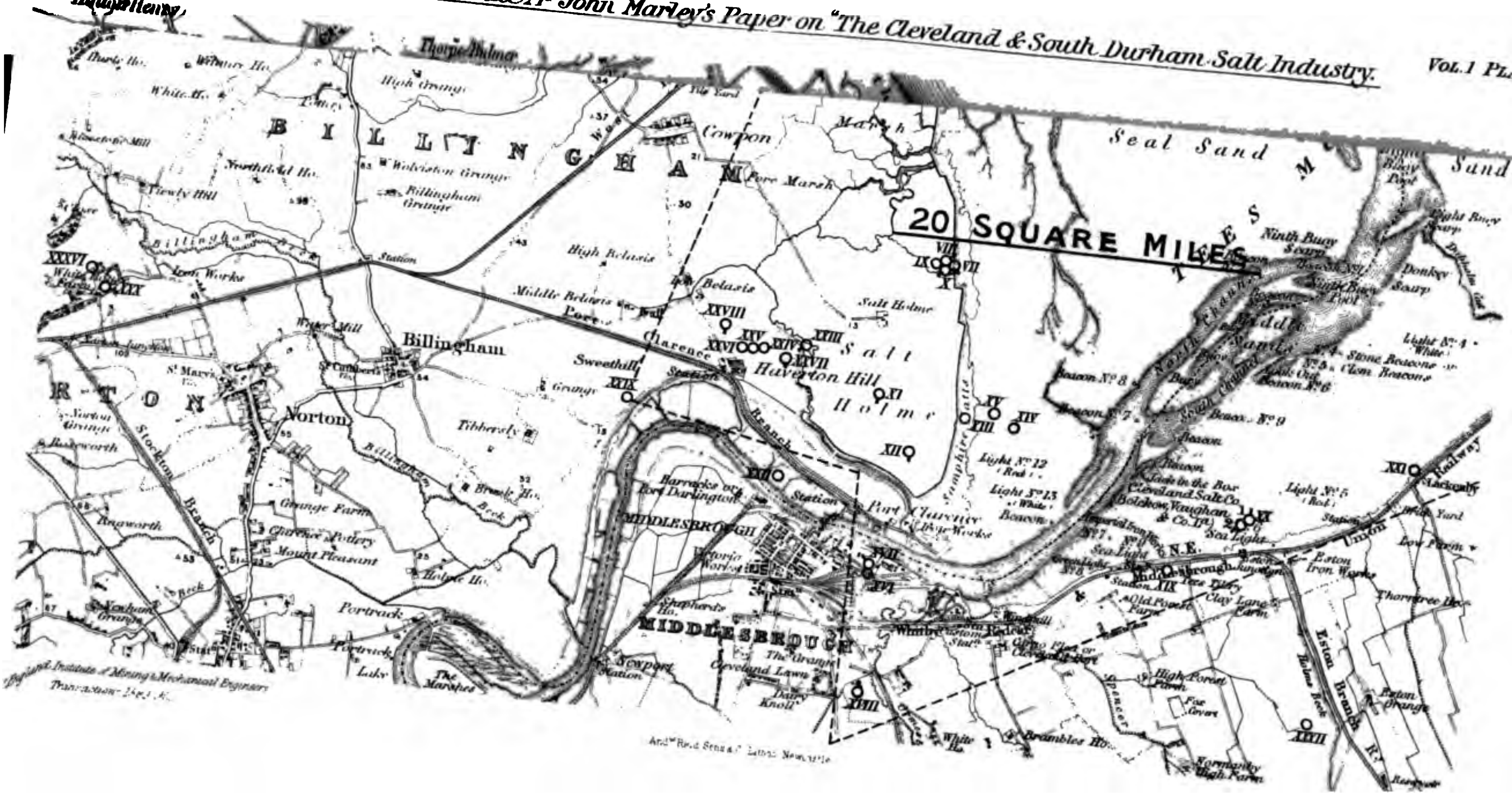
APPENDIX B.—ABSTRACTS OF SECTIONS OF BOREHOLES AND BRINE-WELLS IN CLEVELAND AND SOUTH DURHAM.—*Continued.*

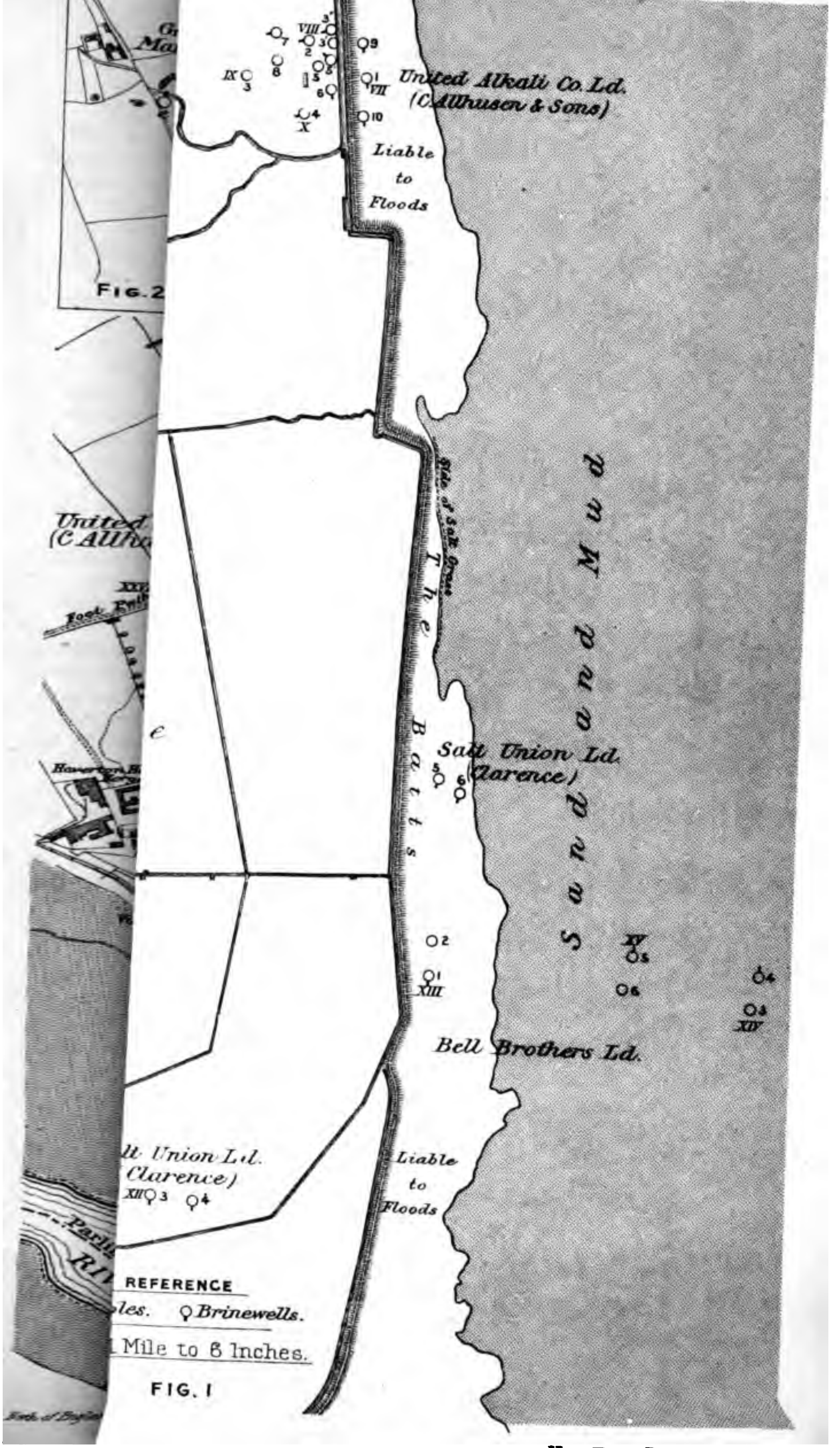
Number of Bore-hole on Plates LIV. and LV.	Situation of Borehole or Brine-well.	Thickness of Surface Deposits.	Upper Gypseous Marls, etc.		Red Sandstones and Marls.		Lower Gypseous Marls.		Saliferous Beds, Anhydrite, and Salts.		Magnesian Limestone and Lower Red Sandstone.		Carboniferous Measures.		Thickness of Salt.			Depth to Bottom of Salt.
			Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Thickness.	Depth from Surface.	Pure.	Mixed.	Total.	
		Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
	Salt Union, Limited—																	
XXIII.	Haverton Hill (South Durham Salt Co., Limited) No. 1	62 9	..	..	588 10	651 7	195 2	846 9	159 7	1,006 4	..	..	..	..	95 4	33 6	128 10	999 2
	" " " " 2	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	98 0	996 0
	" " " " 3	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	91 0	969 0
XXIV.	" " " " 4	69 0	..	..	580 4	649 4	140 6	789 10	135 0	924 10	..	..	..	..	104 6	..	104 6	917 4
	" " " " 5	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	104 0	902 0
	" " " " 6	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	80 0	880 0
	" " " " 7	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	102 0	916 0
	" " " " 8	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	107 0	924 0
	" " " " 9	?	..	..	?	..	?	..	?	..	..	..	..	..	..	..	100 0	978 0
XXV.	Westfield Salt Co., Ld., Haverton Hill* ..	64 8	..	..	492 10	557 6	216 6	774 0	135 2	909 2	..	..	..	..	94 9	8 6	103 3	899 3
XXVI.	Sandfield, Haverton Hill	70 4	..	..	514 9	585 1	185 5	770 6	130 6	901 0	..	..	..	..	87 10	15 5	103 3	900 3
	United Alkali Co., Limited—																	
XXVII.	Haverton Hill (C. Tennant & Prs.) No. 1	83 3	..	..	610 9	694 0	201 3	895 3	118 11	1,014 2	..	..	..	..	72 11	11 10	84 9	1,013 4
	" " " 2*	?	..	..	?	..	?	897 0	113 1	1,010 1	..	..	..	..	83 9	5 4	89 1	1,009 5
	" " " 3†	?	..	..	?	..	?	886 0	112 0	1,008 0	..	..	..	..	76 0	..	76 0	1,002 0
	" " " 4†	?	..	..	?	..	?	901 0	111 0	1,012 0	..	..	..	..	83 0	..	83 0	1,009 0
	" " " 5†	?	..	..	?	..	?	948 0	77 0	1,025 0	..	..	..	..	33 0	10 0	43 0	1,023 0
	" " " 6†	?	..	..	?	..	?	940 0	104 0	1,044 0	..	..	..	..	40 0	10 0	50 0	1,024 0
	" " " 7†	?	..	..	?	..	?	922 0	102 0	1,024 0	..	..	..	..	79 0	..	79 0	1,021 0
	" " " 8†	?	..	..	?	..	?	934 0	90 0	1,024 0	..	..	..	..	50 0	3 0	53 0	1,017 0
XXVIII	Haverton Hill (C. Allhusen & Sons) No. 8a†	70 0	..	..	480 0	550 0	182 0	732 0	76 0	808 0	671 0	1,479 0	694 0	2,173 0	42 0	..	42 0	808 0
	" " " 11†	?	..	..	?	..	?	..	?	..	..	..	..	..	34 0	..	34 0	810 0
	" " " 12†	?	..	..	?	..	?	..	?	..	..	..	..	..	40 0	..	40 0	?
	" " " A†	?	..	..	?	..	?	..	?	..	..	..	..	..	..	9 0	9 0	?
XXIX.	Stonemarsh*	104 9	..	..	497 0	601 9	154 3	756 0	65 9	821 9	178 3	1,000 0	..	..	..	9 0	9 0	793 0
XXX.	White House No. 1*	115 0	..	..	151 0	266 0	130 0	396 0	47 11	443 11	316 9	760 8	318 10	1,079 6	..	..	..	..
XXXI.	Kirklevington	109 2	600 10	710 0	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXII.	Eston, Low Farm	25 0	103 5	128 5	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXIII.	West Coatham	6 0	335 6	341 6	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXIV.	Do.	6 6	129 2	135 8	..	..	..	..	..	..	..	..	..	..	..	..	..	..
XXXV.	Elstob	146 6	..	..	..	..	..	..	..	..	317 6	464 0	428 10	892 10	..	..	..	..
XXXVI.	White House No. 2	134 6	..	..	157 0	291 6	126 4	417 10	46 5	464 3	55 9	520 0	..	..	..	..	..	..

* Diamond-boring. † American boring.

To illustrate Mr. John Marley's Paper on "The Cleveland & South Durham Salt Industry."

Vol. 1 Plate




United Alkali Co. Ld.
(C. Allhusen & Sons)
Liable
to
Floods
Site of Salt Grove
The Batts
Sand and Mud
Salt Union Ld.
(Clarence)
Bell Brothers Ld.
Liable
to
Floods
lt Union Ld.
Clarence)
FIG. 2
REFERENCE
les. Brinewells.
1 Mile to 6 Inches.
FIG. 1

The CHAIRMAN invited comments on the paper, which, however, would be open again for discussion.

Mr. THOS. BELL suggested that when the paper was again discussed an enlarged map should be hung on the wall showing the position of the various boreholes, together with a section showing the position of the different beds bored through. A paper by Mr. T. W. Stuart had been alluded to, and he thought if that gentlemen could be induced either to read that paper or give them some extracts to accompany this one, the different boring-machines being treated of, it would be very interesting; if, however, these machines were mentioned, care should be taken to omit none. There was a dispute among geologists in the district as to whether the Red Sandstone underlaid the Lias.

Prof. LEBOUR—There is no reason to think it does not.

Mr. THOS. BELL.—Could it be proved? He had had some discussion at a meeting of the Manchester Geological Society on the point; they said it was so, but he had given them some notes on the Lackenby Hole to show that it did not. It might; but had any gentleman ever met with a case where it overlapped? The object, however, of his rising was not to ask these questions so much as to propose a vote of thanks to Mr. Marley for his paper.

Mr. J. B. SIMPSON said he had much pleasure in seconding the vote of thanks to Mr. Marley. The paper was a very interesting one, and when it was in the hands of the members they would be better able to consider the points upon which they now required more definite information.

Prof. LEBOUR, in answer to Mr. Bell, said that with regard to the red beds beneath the Lias, unless they actually bored beneath the Lias he did not think they could absolutely prove it, but there was no reason to doubt that the red beds continued in that direction, though one could not tell. That red beds occur in other districts was of course well known. In the Bristol district, for instance, the Lias was to be seen above and the red beds below. That the red beds fell out somewhere to the south there was no doubt; the probability was that the Lias rested on some of the older beds, but he did not see how it could be proved in the North of England except by boring. It was not to be supposed that where they had a considerable thickness of these beds of red sandstone there would be a thinning out immediately.

The CHAIRMAN said they would all agree in passing this vote of thanks. They would also ask Professor Lebour—even if Mr. Marley was not able to attend to it—to make some arrangements for a plan and sections in a conspicuous form for the next meeting, something like Mr. Simpson's well known coal sections.

The CHAIRMAN said he would not offer any further observations—rather reserving till the adjourned discussion anything he might have to say; but he would allude to the extensive discoveries in recent times of valuable salt-beds in other districts than the Tees—among which was that on the West coast near Fleetwood, where, at 100 yards depth, the top of a salt-bed was reached, which had been sunk through and proved to be 100 yards thick. This would be likely to prove a strong competitor with this district.

The vote of thanks was carried with acclamation.

ELECTION OF OFFICERS.

The Scrutineers submitted the list of officers for the ensuing year as follows:—

PRESIDENT.

Wm. Cochrane, Esq., Grainger Street West, Newcastle-upon-Tyne.

VICE-PRESIDENTS.

William Armstrong, Sen., Esq., Pelaw House, Chester-le-Street.

T. J. Bewick, Esq., Suffolk House, Laurence Pountney Hill, London, E.C.

Wm. Lishman, Esq., Bunker Hill, Fence Houses.

G. May, Esq., Harton Colliery, South Shields.

J. B. Simpson, Esq., Hedgefield House, Blaydon-upon-Tyne.

James Willis, Esq., 14, Portland Terrace, Newcastle-upon-Tyne.

COUNCIL.

Henry Armstrong, Esq., Chester-le-Street.

Wm. Armstrong, Jun., Esq., Wingate, Co. Durham.

T. W. Asquith, Esq., Harperley, Lintz Green, Newcastle-upon-Tyne.

Emerson Bainbridge, Esq., Nunnery Colliery Offices, Sheffield.

T. W. Benson, Esq., 11, Newgate Street, Newcastle-upon-Tyne.

R. F. Boyd, Esq., Houghton-le-Spring, Fence Houses, Co. Durham.

M. Walton Brown, Esq., 3, Summerhill Terrace, Newcastle-upon-Tyne.

Sir B. C. Browne, Westacres, Benwell, Newcastle-upon-Tyne.

T. E. Forster, Esq., North Jesmond, Newcastle-upon-Tyne.

T. Heppell, Esq., Leafield House, Birtley, Chester-le-Street.

H. Lawrence, Esq., Grange Iron Works, Durham.

Prof. J. H. Merivale, 2, Victoria Villas, Newcastle-upon-Tyne.

M. W. Parrington, Esq., Wearmouth Colliery, Sunderland.

A. M. Potter, Esq., Shire Moor Colliery, Earsdon, Newcastle-upon-Tyne.

T. H. M. Stratton, Esq., Cramlington House, Northumberland.

J. G. Weeks, Esq., Bedlington, R.S.O., Northumberland.

R. L. Weeks, Esq., Willington, Co. Durham.

W. O. Wood, Esq., South Hetton, Sunderland.

Mr. A. L. STEAVENSON said he had much pleasure in congratulating their new President; he hoped he might have many years of health and strength to enjoy a successful presidentship.

Mr. COCHRANE said he felt very proud of the honour which the members had done him, and he assured them that he would do his best to add to the success of the Institute. He felt a little nervous about taking the presidency under any circumstances, and it looked as if he were afraid of the position when he told them that he was going away for a time; he hoped, however, when he came back that he would have good health to enable him to devote his energies to their interests. The Institute would not suffer by his absence, for he knew he could rely on the band of Past-Presidents who were ready to support him, and without whose assistance and that of the Council he could not undertake the work. He felt certain that under the circumstances, and knowing that he had gone away for his health's sake, they would conduct the affairs of the Institute, in his absence, as well, and perhaps better, than he could have done. He thanked them cordially.

Mr. J. B. SIMPSON said there was one duty they must not overlook. There was an old proverb that it was better to be off with the old love before they were on with the new; and they ought not to part to-day without emphasizing their thanks to Mr. Marley for the manner in which he had conducted the affairs of the Institute

for the past two years, their sympathy with him in his illness, and the hope that he might be soon recovered and able to come amongst them again. They all knew that Mr. Marley had thrown his whole heart into the work of the Mining Institute, and they ought therefore to convey to him in some manner their appreciation of the very able manner in which he had conducted their proceedings.

Mr. COCHRANE could only say that taking the chair after Mr. Marley was one of the serious things he had to face. Mr. Marley had unreservedly devoted his time and attention to the interests of the Institute, he had done all that a President could be expected to do, and he thought the members would admit that the Institute had prospered in consequence. He would be happy to convey to Mr. Marley personally and by letter the kind expressions to which Mr. Simpson had given utterance, and the manner in which these had been received. He was very pleased to second Mr. Simpson's motion.

The vote of thanks to the retiring President was heartily adopted.

Mr. JAS. WILLIS proposed a vote of thanks to the Scrutineers. The task of these gentlemen was an unwelcome one, and occupied considerable time which they might have spent much more pleasurably in listening to the interesting papers and discussions.

Mr. SIMPSON seconded the proposal, which was unanimously approved.

LECTURE THEATRE.

The PRESIDENT said that before closing the meeting he would call the attention of the members to the arrangements in connexion with the lecture theatre. They could now see from the window the white glazed bricks of the passage which enclosed the new ground they held from the railway company. The only drawback to this acquisition was that it would be dark when the railway company's buildings were completed. The only natural light they would have in the lecture theatre would be from the end windows. The question of lighting by electricity or some other mode would, however, come before the Council in due course. He would also like to call attention to an adjoining room, in which the whole of their stock of Proceedings had been very conveniently arranged by Mr. Gosman. Although the stock had been put there at some little cost, he thought they would all agree that the manner in which it was now stored was very efficient, and they could obtain information at any moment as to the volumes in hand.

Mr. BELL asked if the Council had agreed to the railway company closing the side windows?

The PRESIDENT explained that the Institute never had any right of light in that direction; they had always paid an acknowledgment of 5s. a year for it, and now that the railway company had purchased the adjoining property they had power to build close to the windows.

The PRESIDENT announced that the next meeting of the Federated Institution would take place at Nottingham, on the 24th and 25th of September, when he hoped many members from the North of England would attend. There would be every inducement, for the colliery owners there were taking the matter up strenuously. He was sorry he would not be there himself; but he hoped the meeting would be—as it promised to be—a success, and that the members would enjoy it thoroughly.

The meeting then concluded.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE ROOMS OF THE INSTITUTION OF CIVIL ENGINEERS, 25, GREAT GEORGE STREET, WESTMINSTER, APRIL 30TH, 1890.*

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

Mr. W. TOPLEY read the following paper on "Coal in Kent":—

COAL IN KENT.

BY W. TOPLEY.

The recent discovery of coal at Dover has given additional interest to a question about which much has been said during the last thirty-five years. Hitherto the subject has been in large part merely one of speculation, and although the evidence for the probable existence of Coal-measures beneath the south-east of England has long been sufficient to satisfy almost every geologist who has studied the subject, yet scepticism was perhaps excusable in the minds of others. Now, however, so far as the neighbourhood of Dover is concerned, the question has passed from speculation to certainty, and it may be desirable to review the evidence concerning what is likely to occur elsewhere, beneath the south-east of England.

The occurrence of "coal" in the Wealden district of the south-east of England is an old story. Again and again have we read of coal having been discovered, and various attempts have been made to work it. But in every case this so-called "coal" is merely a variety of lignite, which occurs in the Wealden strata; the beds are very irregular, they are generally only a few inches thick, but here and there they exceed this. Some seams, exposed on the shore at Bexhill, led to a serious attempt to win the coal some eighty years back. A shaft was sunk, and a seam, 3 or 4 feet thick, was said to have been discovered, but various troubles, chiefly water, beset the enterprise, and the work was soon abandoned.

It is an easy matter for us in these days to laugh at the mistakes of other times; but the truth is, that such explorations for coal in Sussex were much more sensible than is now generally thought. The alternations of sandstone, sand, and shale, or clay, of which the central Wealden area consists, greatly resemble the beds of the true Coal-measures, and the natural features of the country are much alike. Alternations of stiff and light soil, and steep-sided "gills," furrowing the surface, characterize alike the Weald and many coal-fields. Clay-ironstone, too, occurs in both, and this was formerly largely worked and smelted in the Weald. Probably the old explorers contented themselves with comparing the surface-features and the general nature of the rocks of the two areas; but if they paid any attention to fossils, they would naturally take the ferns, the *Equisetum*, and the *Unio* of the Wealden Beds to represent the ferns, *Calamites*, and *Anthracosia* of the Coal-measures.

* Continued from page 187.

It is not worth while further to discuss this question; but one may note with pleasure that the man who first clearly understood the general structure of the Weald, and who persistently warned speculators of their mistake, was John Farey, so well-known as a practical mining engineer in Derbyshire and elsewhere. A MS. section across the Wealden area, made by him in 1807, is here exhibited; it clearly shows the general succession of the beds, and also the great anticlinal of the Weald, the summit of which he correctly placed. In describing this section, Farey introduced the term "denudation," which has since done such excellent service in geology.

Passing over the general history of geological research in the district, as not immediately bearing on our subject, we will merely enquire what was the universal opinion as to the structure of the south-east of England up to about the year 1855.

The Chalk and underlying Gault were held to underlie, in basin-shaped form, the Tertiary area on which London is built, and this inference all subsequent researches have confirmed. But below the Gault, the Lower Greensand crops out on the south and north of London, and it was naturally thought that this formation would continue beneath the London basin. Below the Lower Greensand on the south come thick beds of the Wealden Series, whilst on the north there are the marine beds of the Jurassic Series. It was not known how far north the Wealden Beds would go, but it was believed that either Wealden or Jurassic Beds, or both, would underlie London to an indefinite depth.

Recent researches have proved that so far as the lower beds are concerned these early opinions as to the structure of the London basin are incorrect. We know that only a small part of the Lower Greensand and a very small part of the Jurassic Beds exist under London, and that sometimes even these are absent; and then the Gault (with a sandy base, which perhaps represents the top of the Lower Greensand) rests directly upon the Palæozoic rocks. These rocks, instead of being several thousands of feet beneath the surface, vary in depth, so far as is at present known, from 710 feet below Ordnance datum at Ware to 1,222 feet at Richmond.

Although probably no one doubted the existence of a deep basin under London and a great thickness of Secondary rocks, many geologists had noted the fact that the Palæozoic rocks, where they came to the surface on the west and east, had a general similarity of structure and character, and not a few drew the inference that a similar structure might be deeply hidden beneath the Secondary rocks of the south of England.

In 1822, Dr. Buckland and Mr. Conybeare, in describing the Bristol coal-field,* said:—"Before we close this general account of the south-western coal district of England, we are desirous of noticing its resemblance in geological structure and picturesque features to the country extending along the Meuse, between Namur and Liège. There also we are presented with coal basins encircled by Mountain Limestone, and based on Old Red Sandstone, which latter is displayed at Huy. These rocks are all highly inclined, and are covered by overlying formations. The defiles of the Sambre and Meuse present exact counterparts to those of the Avon and Wye."

A clearer statement was the following by Sir H. de la Beche, in 1846,† in describing the rocks of the west of England:—"From the movement of the older rocks many a mass of Coal-measures may be buried beneath the Oolites and Cretaceous rocks on the east, the remains of a great sheet of these accumulations, connecting the districts we have noticed with those of central England and of Belgium, rolled about, and partially denuded prior to the deposit of the new Red Sandstone."

* Trans. Geol. Soc., ser. 2, vol. i., page 220.

† Mem. Geol. Survey, vol. i., page 214.

In 1848, Mr. M. Dunn, in his "Winning and Working of Collieries," referred to this question as follows:—"Although Chalk, in Britain, is always considered most remote from any connection with coal strata, yet it prevails to a great extent over the coal-fields of France and Belgium, and especially in the district of Mons, where the Grand Hornu Colliery is sunk through 210 feet of Chalk. On its course westward it increases in thickness, and it has been proved to the depth of 400 feet. . . . There is no reason to doubt that it is continuous to the cliffs of Dover; in which case it suggests the very curious and important question as to whether or not the Carboniferous coal-fields of Belgium* exist under the similar Chalk formation of Britain."

The general similarity of the coal-fields of the west of England to that of the Franco-Belgian area has been plain to all geologists and mining engineers who are acquainted with both districts. The great number and the comparative thinness of the seams, the variation in the character of the coal from anthracite to highly bituminous coal, and certain small points of similarity, such as the oblique fracture of the coal, special lithological character in bands of ironstone, etc., are points which, taken together, stamp the Franco-Belgian coal-field as far more resembling those of the west of England than any others in this country.

Coal had long been worked in Belgium where it crops to the surface. It was then followed westward under the Secondary and Tertiary rocks.

In 1720 coal was first worked in the Department du Nord, but it was not till 1846 that it was discovered in the eastern part of the Pas de Calais; this discovery (at Oignies) was accidentally made in sinking for water. The rapidity with which this discovery was followed up is remarkable, offering a striking contrast to the indifference with which such subjects are generally treated in England. By 1850 eighteen concessions were granted in the Pas de Calais, and up to 1855 sixty-eight borings had been made, thirty-five of which reached Coal-measures; and thirty-three reached rocks older than Coal-measures.

French geologists were not long in surmising that the coal and its associated older strata thus proved beneath the Secondary rocks of Northern France might well in like manner underlie the south-east of England. M. Mengy, in 1852,† suggested this, and further pointed out the probability of the coal occurring on the southern side of London.

To English geologists the question first assumed importance through the publication of Mr. Godwin-Austen's remarkable paper in 1856.‡

It is not necessary here to go over Mr. Godwin-Austen's arguments in detail, or the fuller statement of the case presented by Prof. Prestwich in his Report to the Royal Coal Commission in 1871. These points are well known to all who take an interest in the matter. Suffice it to say that Mr. Godwin-Austen showed most clearly that the band of Palæozoic rocks containing coal, which come to the surface in Belgium, and had been proved to underlie the Cretaceous and Tertiary rocks in the north-west of France, was the same as that which came to the surface in the west of England, where also it disappeared under Secondary rocks to the east; and he inferred that this same band of Palæozoic rocks ranged beneath the south-east of England.

He gave other reasons for believing that the Secondary rocks were thinner under London than had been previously supposed, and that consequently the Palæozoic rocks would there be found at a comparatively small depth.

* This quotation is from the second edition, page 8, 1852.

† "Essai de géologie pratique sur la Flandre Française," page 76.

‡ "On the Possible Extension of the Coal-measures beneath the South-East of England."—*Quart. Journ. Geol. Soc.*, vol. xii., pp. 38-73. (The paper was read to the society on May 30th, 1856.)

The truth of this supposition was proved (before the paper was published) by the well at Kentish Town, which reached old rocks at a depth of 1,114 feet, and also by one at Harwich, where Lower Carboniferous rocks (with *Posidonomya*) were reached at a depth of 1,029 feet.

Prof. Hull had also been working at the question of the varying thickness of the Secondary rocks in the south-east of England, and he had shown that they all probably thin away to the south-east towards London. This thinning he attributed to failure of sediment in that direction, not to the deposits being banked against an old ridge. This difference of view is of some theoretical importance, and probably Prof. Hull's view is the correct one.

Deep borings have been made in the London basin for water supply, promoted chiefly by the success which had attended the Grenelle boring at Paris, where water was obtained from the Lower Greensand. As the Lower Greensand was then believed to extend without interruption across the London basin beneath London, and as this was known to be an excellent water-bearing stratum near the outcrop, there was every reason to look to this as a deep source of supply for London itself.

The first boring to test this was at Kentish Town (completed in 1855) which traversed the Tertiary beds, Chalk, and Gault in regular sequence, and then went into Red Sandstone, with some reddish clays, which were proved to a thickness of 188½ feet. No supply of water was obtained from the Chalk.

Other borings followed, all alike unsuccessful in obtaining water; some touched a small thickness of Lower Greensand, three passed also through Jurassic beds, but others passed direct from the Gault to the older rocks.

The general result of these borings may be stated as follows (Plate LVI.):—To the north of London, at Ware, Upper Silurian (Wenlock) rocks occur with only 18 inches of Lower Greensand. Farther south Upper Devonian rocks occur at Turnford, near Cheshunt, and at Meux's Brewery, in London, near where Tottenham Court Road joins Oxford Street. At Cheshunt the Gault rests directly on the Devonian rocks; but at Meux's Brewery 64 feet of Great Oolite strata intervene.

At Kentish Town, Crossness, Richmond and Streatham, Red rocks of uncertain age have been found; at Richmond and Streatham Oolitic strata occurred between the Cretaceous strata and the Red rocks.

The borings show that while the Secondary rocks are apparently horizontal, the older rocks are inclined from 20 degs. to 30 degs.; but we have usually no means of knowing in what direction the beds dip. Experiments were made with the boreholes at Cheshunt and Ware by a committee consisting of Sir W. Thomson, Sir G. Stokes, Prof. Clerk Maxwell, Prof. G. H. Darwin, T. McK. Hughes, and others, to ascertain if possible the direction of the dip of the beds; this committee concluded that the dip was toward the south, as would have been expected; but we have no evidence as to the dip in other boreholes. But from all the evidence at hand we are perhaps justified in concluding that the Silurian rocks lie wholly to the north of London, whilst the Devonian rocks lie in a band under the northern half of London. The southern half of London is underlain by Red rocks of uncertain age, similar rocks occurring also under Kentish Town.

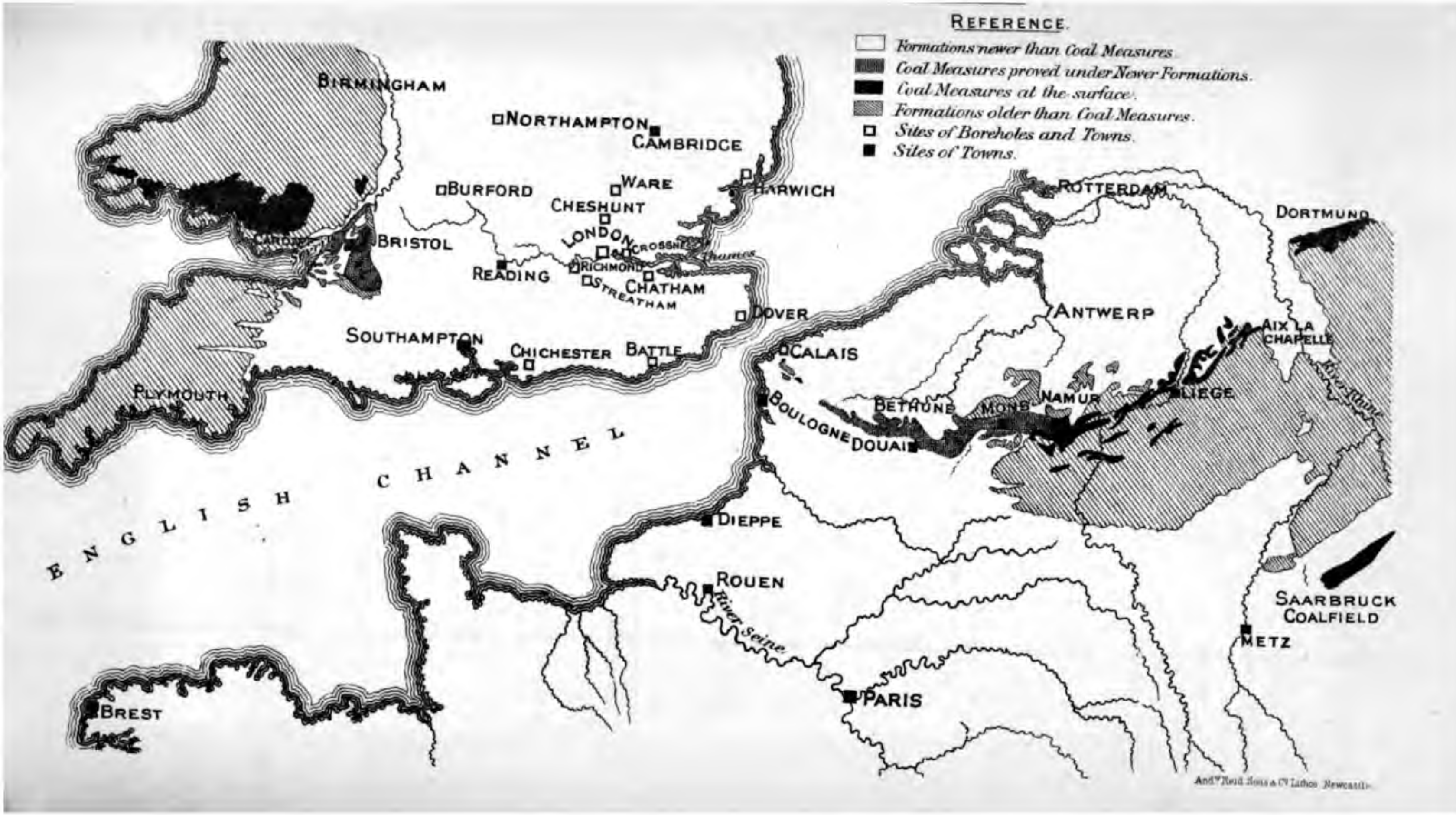
The age of the Red Sandstone, etc., met with at Crossness, Richmond, Streatham, and Kentish Town, is a question of great importance. If the beds are New Red Sandstone (or Trias) coal may occur below; if Old Red Sandstone or Lower Carboniferous this is unlikely, except in the case of overthrust faults or inversions.

Lithologically, there is not much to guide us. For the most part the cores would do equally well for either. Many of the cores, however, brought up from the Streatham boring are more like Old Red or Carboniferous Sandstone than like New

Red. Against the New Red view we have the important fact that wherever the Jurassic rock and the Trias occur in succession there is a complete conformity passing downwards. We should not expect to find Jurassic rocks horizontal and the underlying Trias with a marked dip. Further, there is the fact that none of the numerous borings in the north of France have met with Triassic rocks.

When speaking of the rocks as "Old Red" we only mean that they, lithologically, resemble the Old Red, not that they would necessarily be of the fresh-water type of Old Red such as occurs in Scotland and probably also in Herefordshire, etc. Among the marine Devonian rocks of Devonshire there are great thicknesses of reddish beds which might well represent the doubtful rocks under consideration; and in the lower part of the Belgian Devonian there are thick beds of Red Sandstone, etc. (the beds of Burnot), which may also represent them. Rocks of this kind would naturally vary rapidly in character, and we cannot expect exactly to identify such unfossiliferous strata in distant localities. The Culm-measures of Devonshire are believed to represent the Lower Carboniferous rocks and possibly also a part of the Coal-measures. There is, of course, a possibility that these beds may occur beneath the south-east of England. They, however, are rarely red, and they do not resemble the Red beds in question. Moreover the true Coal-measures and the Carboniferous Limestone occur in the Bristol coal-field and the north of France; it is reasonable therefore to assume that they will likewise so occur in the intermediate area. If the unproductive Lower Coal-measures of the Culm-measure type extend to the east that will probably be far to the south of the area with which we are now concerned.

Mr. G. C. Greenwell sent the following communication, which was read by the Secretary:—"The exploration of coal at no great distance under the Chalk has long taken place in the North of France, as is shown in the work of *Morand le Médécin* and in the fine atlas published with it in the year 1819. It is needless to go historically into the question and discuss the *pros* and *cons* as to the continuation to and through the southern counties of England. Upon this, in 1864, he wrote a paper for the Manchester Geological Society with the object of showing the probability of the thinning of many of the formations above the Carboniferous in passing eastward from Somersetshire, and that at no great depth coal might be found in England's south-eastern and southern counties, ranging from the North of France towards Somersetshire and South Wales. The Carboniferous rocks and coal have been bored into near Shakespere's Cliff. The thickness of the coal found at some 1,200 or 1,300 feet from the surface has not, so far as he knew, been as yet disclosed. What are the conclusions which we can at present possibly arrive at? We must compare the nearest coal-fields between which the borehole is placed. These are that of the North of France and that of Somersetshire. In the southern part of each of these, the strata, driven northwards by southern upheaval, are contorted in an extraordinary degree; this has been proved to a much greater extent in the North of France than in Somersetshire, for the simple reason that the pits are very much deeper and the explorations far more extensive. So far, however, as explorings and workings in Somersetshire (at Vobster and in the neighbourhood) have gone the contortions and zigzag character of the strata and coal-seams are identical. The quality of the 'gras' coal of these southern and contorted seams of the North of France is apparently the same as that of the seams of the southern and contorted field of Somerset. It may, therefore, be in-


REFERENCE.
Formations newer than Coal Measures.
Coal Measures proved under Newer Formations.
Coal Measures at the surface.
Formations older than Coal Measures.
Sites of Boreholes and Towns.
Sites of Towns.
BIRMINGHAM
NORTHAMPTON
CAMBRIDGE
BURFORD
WARE
CHESHUNT
LONDON
BRISTOL
READING
RICHMOND
STREATHAM
CHATHAM
Thames
DOVER
SOUTHAMPTON
CHICHESTER
BATTLE
PLYMOUTH
ENGLISH CHANNEL
ROTTERDAM
DORTMUND
ANTWERP
AIX LA CHAPELLE
River Rhine
CALAIS
BETHUNE
MONS
NAMUR
LIEGE
BOULOGNE
DOUAI
DIEPPE
ROUEN
River Seine
PARIS
BREST
SAARBRUCK COALFIELD
METZ
Andw Reid Sons & Co Lithos Newcastle

ferred that these are identical, and that, from the position of the Dover borehole, there is a strong probability at least of zigzag seams being found there. Northward from this probable southern boundary of the belt, the overlying portions of the formation will very likely, as in France and Somersetshire, produce coals of a less bituminous character. The coals lying generally in sections of great irregularity of dip, often even vertical, any proof by boring (except where the boring is of such dimensions and so managed as to allow of cores being obtained) as to the thickness of a seam bored through is impossible for obvious reasons. The seams of the North of France are usually thin, say 15 inches to 30 or 32 inches, and similar ones would be, in this country and so near London, very expensive to work. No doubt the time will come when the coal of the South of England will be of great value. but, unless the writer is greatly mistaken, so long as the coal of the North of England is available it will be delivered more cheaply at Dover than it will be worked there."

Mr. DAGLISH said he would like to ask Mr. Topley about one or two points dealt with in the paper. In the first place it was mentioned that the temperature in very deep workings in Belgium was only 59 degrees Fahr. He had not had much opportunity of going into that question, but in the North of England they had much higher temperatures at much less depth. At Seaham Colliery, for instance, at a depth of 250 fathoms the normal temperature was 74 degrees. That temperature was not arrived at until the air had passed a considerable distance towards the working faces, the ventilation nearer the downcast shaft being sufficient to keep the temperature down, but it was attained after passing a certain distance in the back workings, and retained it until it ascended the upcast shaft. The other point he wished to mention was as to the quantity of water met with in the shafts, and which Mr. Topley thought would not be great, but he (Mr. Daglish) thought that in some of the Belgian sinkings large quantities of water had been met with in the Chalk beds. In some parts no doubt the formation was almost impervious to water, but in others, especially where there were many fissures, a very large quantity of water was passed. Of course in the North of England where they had the Magnesian Limestone, large quantities of water were met with; it was also met with extensively in the Carboniferous Limestone, and he thought it would be met with in the Chalk beds described, where there were large fissures.

Mr. G. B. WALKER said he would like to ask two questions, although perhaps one ought to know something in regard to the first from reading of the subject in the papers. Was the coal proved at Dover found in a horizontal or inclined position? Of course if it were highly inclined the apparent thickness in the boring would be greater than was actually the case. The other point was one on which it might perhaps be impossible to give an answer, but he would ask it nevertheless. He presumed the idea was that they had under the London Basin a denuded anticlinal, and perhaps it might be a larger one than had been proved by the explorations hitherto. If the inclination of the Silurian and Devonian rocks was as proved at Ware, at some point between Ware and London there was a southerly dip, and even allowing for fractures in the anticlinal, there should be a northerly dip somewhere further to the north. If the sketch on the blackboard represented the Coal-measures in the left hand corner (perhaps it did not break off sufficiently in the sketch), but if the Coal-measures were inclined against the lower rocks on the London Basin, it was possible that at some point farther north they might be found dipping in the opposite direction. That, of course, would not be justified by the experience in Belgium, but the peculiar structure of the Belgian coal-fields led him to ask if he was right in assuming that the coal-field could be considered a denuded anticlinal, or whether it was a foreign upthrow of lower beds?

Prof. McKenny Hughes said that Mr. Topley was better acquainted with the subject than anyone else, unless it might be Mr. Whitaker, who also was present. He (Prof. Hughes) would therefore confine himself to certain points which had been raised in the discussion, for instance, the last question as to anticlinals or upthrust faults. The first thing anyone making an investigation of this kind asked was, what probabilities were arrived at of there being folds in the region where they hoped to explore the coal of similar character to those observed in the nearest known coal-fields; he thought that was the question involved in the one put by the last speaker. There was little connexion between the folds and ridges which we can observe at the surface, and the subterranean uplift which would bring the coal within workable distance of the surface. Instead of the gentle dip of the northern edge of the London Basin, they had, in the section shown in the diagram on the wall, a slightly more rapid rise on the south side, and the Chalk, etc., which dipped gently from Hampshire under the Isle of Wight, turned up sharply about the Needles; but following the Cretaceous beds away to the west, they lay almost horizontally across the edges of the older beds that were folded, as in the Coal-measures, and which had been previously thrown into anticlinal and synclinal folds; it was therefore impossible to know the nature of older folds from observations of those which show themselves in the newer rocks. It must also be remembered that an anticlinal fold was only the first step of an overthrust fault. There were other points which might be raised in the course of such enquiries as this, which were perhaps not quite foreign to the subject of the paper itself; one of these he had brought forward before, when Mr. Whitaker read a paper on the subject, viz., the probability of having coal not belonging to the disturbed ridges of Coal-measures, but curving south and west into the Thames estuary from the seaside near Harwich. At Harwich the Lower Coal-measures were touched, and they had got still older beds than even the Lower Coal-measures to the west, near Ware, while there were the Archaean rocks away to the west of that again, and they knew that the only dip they had of these older rocks was to the south, at Ware. Following these curves they ought to get coal-bearing strata running from the east side of Harwich, curving down into the London Basin, and there assuming an east and west direction, if they took the strike of the last rock they found in the Hertfordshire borings. They there got into a very likely line of country for profitable investigation, farther north than the area brought before them in the present discussion.

Mr. Bauerman said that Mr. Topley had gone very fully into all the matters treated of in the paper, and the only subject on which he might say a word of interest to the meeting was that of the overthrust. Those of them who were at the Paris Exhibition last year were very much surprised no doubt at the great development in that direction on the south side. About the centre of the North of France coal-field frequently when concessions were taken up borings were taken, and when they struck Devonian rocks they were abandoned, and the boundary of the concession laid out to the north. Some years ago, however, there was a pit at Courriéres where they went down for something like 350 yards, he believed, working a series of coals, but below that point they found the same series though in reverse order, which showed that in the higher levels the beds were completely inverted. Since that time the principle had been followed of going to the south of what was supposed to be the limit of the coal-field; and in one pit at Drocourt the section exhibited last year showed Chalk and Wealden overlying a considerable thickness of Devonian shale. They were followed in depth by about 1,000 feet of broken and crushed Coal-measures, below which came undisturbed Coal-measures, dipping regularly from south to north, and the output now exceeds 200,000 tons per annum of as good gas and coking coal as in the best part of the coal-field. This

remarkable discovery showed that there was more coal south of that coal-field than people had ever dreamed of. As regards folds, it was true that in Belgium the coal-field was squeezed up very much—9 miles were compressed into 4 as far as he could remember—but both in South Wales and Westphalia the folds were small. There were several anticlinals in Westphalia, but nothing like those in Belgium.

Mr. EMERSON BAINBRIDGE said that the final part of the paper referred to a question of present interest, as to whether further exploration should be carried out, and as to what ought to be the result of such exploration. The present boreholes showed some peculiarities, and seemed to give little encouragement for the belief that coal would be found there. At Dover they had coal just below the Chalk; the Chatham boring lost itself in the Gault; and the Sub-Wealden boring went down to the Middle Oolite—how much farther they would have to go before getting to the Coal-measures it was impossible to say. In both cases there seemed to be a thinning towards the east. The greatest irregularity seemed to exist, and it led to the idea that the distortions referred to in the paper occurred in the neighbourhood of Dover. Mr. Topley would probably say it was impossible to tell by such a borehole as was put down whether the coal was vertical or horizontal, but he would perhaps let them know how far the borehole went into the coal, and next, what was the diameter of the borehole.

Mr. WHITAKER said as he had had the pleasure of being the first to publish an account of the Chatham borehole, he might perhaps make a statement with regard to what the last speaker had said. Unfortunately, that gentleman had fallen into some mistake as to what was found; the Chatham borehole ended in the same rocks as the Sub-Wealden, but instead of going 1,900 feet at Chatham they only went 900, and these 900 feet consisted of rocks which did not exist at Battle; the proper inference to draw from the two was that coal would be found infinitely nearer at Chatham than at Battle. And it must be remembered that though they had no details of the Dover boring before them, this work fully bore out the above conclusion, for at Dover on the north-east the whole of the Oolites were found to be less than 700 feet thick, whilst near Battle two-thirds of them were 1,900 feet. At Chatham they had every reason to expect results more like Dover, or even better, for the Upper Oolites were represented at Dover, and not an inch of them, so far as he knew, at Chatham. In the paper Mr. Topley alluded to the rapidity with which the discovery of those underlying Coal-measures was followed up in France, the rapidity with which the trial borings were made and then followed up by coal-working, and contrasted that with the more sluggish procedure in England. That comparison might also be made with other countries than France. He was reading that morning in the Proceedings of the Institution of Civil Engineers an account of trial borings in Germany, one of which, under the charge of the Government mining engineer, went to over 5,000 feet, but was unsuccessful except in the matter of measuring temperatures. It was in that respect eminently successful. A steady increase was found of 6 or 7 degrees Fahrenheit for every 100 feet; that was of course without any ventilation at all. He forgot the temperature—139 or 159 degrees—but he thought the mention of the boring might be interesting. It began with a diameter of a little over 11 inches and ended with 1¼, and was made to find coal and brine. He did not learn from the account that it succeeded. This was the sort of thing they could not get the British Government to do. In the case of Chatham they certainly had a boring well placed, not only being a good site topographically, but having already been carried to a depth of over 960 feet: a further 500 feet would probably solve the question as far as that particular neighbourhood was concerned. He thought it very unlikely that they would have more than 400 feet of Oolites before getting to older rocks. Allusion had been made to the smallness of the

cores at Harwich; there were a few of these at Jermyn Street. They were some of the prettiest cores in the London Basin, showing the cleavage as well as the dip of the rocks, crossing the dip at a high angle, and they, no doubt, got into the Lower Carboniferous rocks. The later borings only went about 60 feet, and, therefore, they knew little of them. In Essex and Suffolk they required further information; whether the newer rocks would be found east, north, or west they could not say. He must differ from the author in one little matter, although he was afraid most people would take the view given in the paper at first sight; it was stated that all the borings in the London Basin failed in the question of water except Chatham, where a certain quantity was found in the Greensand. The Streatham boring was an eminent success though it did not go very deep down, a million or a million and a half gallons could be pumped from it, and the whole of the work was done to about 150 feet from the surface through water which came from the top of the Chalk; he believed the well would be used although the deep boring was unsuccessful in coming to water. Then came the question as to the dip of the older rocks, and he was very much inclined to say he did not know in what direction they dipped, and to add that he didn't care, for he did not think it mattered. It had been inferred that because we had older rocks at Ware and slightly newer towards and under London, there was a general dip from north to south. There might be, but the distance from Ware to London was a long distance and sufficient for many interruptions to take effect. If the fact was established that at Ware the dip was southerly, that farther south it was also southerly, and at London also, he would not like it to be inferred that in the intervening space it was not north, east, or west, or any other direction. He thought the inclination would be a local one only. He must take the blame for the exaggeration on the diagram of the Coal-measures found in the Dover boring. The formation of the Bristol coal-field was peculiar, there being a sandstone about 2,000 feet thick, and he thought there was little fear of that kind of thing in these eastern coal-fields; and as in one district the Coal-measures consist of alternations of coal and shale simply, in another there were masses of sandstone as in Yorkshire. So they must expect in these underground extensions and coal-fields if they occur, as he had no doubt they did, that similar varieties of detail in the structure would also happen. The Charleroi Pit, with a depth of 3,000 feet, was equalled in depth by some in England. We were often met with the idea that the coal was so deep that it would not pay to work it. If one thing was certain, however, it was that if coal did occur in the south-east of England it would occur at distinctly workable depths. The evidence from all the borings—and there were now some eight or ten—showed that the older rocks were nearly always touched at depths varying from 800 and 900 to 1,200 and 1,300 feet from the surface, and that was no great depth: it might be a great depth for a water well, but not for a colliery where good coal was to be got. The question of water, too, was very important. Mr. Topley had remarked that there would be little trouble from water, but he (the speaker) was inclined to think in some cases water would be a positive advantage. He could name a good many places where if a shaft was sunk and water was found they would get not only the thanks of the inhabitants of the district but also a considerable profit. Even if they failed in getting coal they would probably make the venture pay with water. But there would not be large quantities in the Weald and other districts where there were alternations of sand and clay. The sand was so very fine that it might almost be considered a modified kind of clay; it was so densely packed as not to be water-bearing, and where water was found at all it would be near the surface, where it could be easily dealt with. To the districts mentioned in the paper as where it was likely that borings might be put down with

satisfactory results, he would be inclined to add a rather more westerly district, far west of London or Reading. Along the district known as the Vale of Pusey there was an upheaval. In that particular district they knew nothing of what was to be found 200 feet down, below the Upper Greensand, which was brought up by the upheaval. The only information possessed was on a section of the Geological Survey, in which the late Director of the English Survey was bold enough to colour—and perfectly safely at first sight—the Gault, and under the Gault the Kimmeridge Clay. It would be very satisfactory to have a boring in that district, because if the Kimmeridge Clay were touched in that district something older would be got at no enormous depth. He was rather inclined to hope that as it was on the verge of Hampshire and Berkshire some of the Hampshire folk might be led to try experiments. A small Hampshire society, at a meeting on Tuesday, appointed a committee to promote explorations in that county; at all events to keep their eyes open, and suggest to landlords likely spots for experiments. Undoubtedly it would be wrong, as Mr. Topley said, to trust to one boring. The danger was that if they trusted to one boring and it failed, that failure in one particular spot was allowed by the majority of people to mean failure everywhere. That was really what happened with the Sub-Wealden boring. The Sub-Wealden boring was made to get something, and it did, but the promoters did not specify coal as the thing sought for, only knowledge; but the fact that the Secondary rocks were not pierced was no reason why other borings some way off would not be successful in getting to older rocks. It was, however, the danger of negative results ensuing in the first case that dispirited people, and it was all the more lucky that the Dover boring—the only one made in the London Basin to find coal—had succeeded, because the result would probably be to encourage people, possibly to over-encourage them, and they might want to go and seek for coal—well, where they had better not. The advisability of having a shaft instead of a boring, if it could be arranged, was very well illustrated in this particular case. Mr. Topley had been asked a considerable number of questions which he had the greatest possible pleasure in leaving him to answer—if he could! With a shaft it would have been possible, but with a boring, on the "jam-jam" principle, it was not likely that they could have very full particulars of the results, the material being much smashed. He must say that he wished the Government could be induced to carry on that Chatham boring. He did not know how to deal with the Government—they had dealt with him over thirty odd years, and he had dealt with them to some extent in doing to the best of his power what they told him to do, but he had no idea how to impress upon them how to do anything. The Government was a wonderful body altogether, more wonderful even than the Federated Institution of Mining Engineers, whom one might be able to impress with the advisability of work of that kind. But if Government could be got to allow that boring to be continued, or to do the work itself, it would really be a very good thing, and as it would improve the property of the nation in the event of a successful result, he thought it should be done as a national matter. He thought, two or three years ago, that he had looked up pretty well the whole of the subject of underground London, but one never did get anything printed without finding out afterwards that something had been omitted. He had since heard of two papers he had missed, and if a paper were to be read a week hence, he would, no doubt, learn something more; but he had of late heard and read so much on this subject that he looked upon it personally as rather a hardship to say more. The meeting had, however, extended its indulgence to him, and he hoped he had not taken up too much time. There was another point not alluded to in the paper, and as the absence of allusion might perhaps cause some little mistake, he would mention it incidentally. They must not expect to find one long general uprise all

the way from Westphalia, through the west of France, underground into the Somerset and South Wales coal-fields, uninterrupted by other uprises. Of course in the South Wales and neighbouring coal-fields there was not only a general anticlinal one way, but cross anticlinals separating these coal-fields; and of such we must expect many in the unproved districts. The borings described in the neighbourhood of London seemed to show that we have one of these cross anticlinals somewhere through the district. The observations of Prof. Rücker on magnetic matters seemed to show there was one extending in the neighbourhood of Chichester, and across these uprises they would get very little in the way of coal. His own impression was that in the neighbourhood of London it was unlikely that coal would be found, unless some of those singular reversed faults occurred. In such cases older beds have been pushed over newer ones, and we may get coal in a good many places where at present we do not think it likely to be found. If we could find anywhere that extraordinary thing Mr. Bauerman described, 1000 feet of broken-up Coal-measures, or broken-up rock of any sort, we should have the right to speculate. There had been some very violent disturbances, but as far as he knew, nothing of this kind had been found in the deep borings; the moment it did occur—if it ever did—it would be decided that there was the place where there should be a considerable amount of investigation. He held that from what is known either at the surface in the West of England or in the North of France or Belgium, supplemented by underground work in the West of England, and more markedly in the North of France, and by deep borings in England—which failed utterly in their object of getting water, but have given us a knowledge even more valuable—that somewhere or other, the precise line one could not determine, there certainly was an uprise of older rocks, probably somewhere along a line from South Wales to Dover, and that amongst those older rocks, that most valuable of all rocks, old and new, the Coal-measures would be found, and that they would contain workable coal, and at workable depths.

Mr. Topley said his reply need not be long, as the questions of the first speakers had to some extent been answered by the others. There were one or two things, however, which he might refer to. In reply to Mr. Daglish's question about the temperature figures, he believed they were taken from the official reports, which had just appeared, of the Paris Exhibition; if not there, it was probably from a comparatively recent abstract in the Proceedings of the Institution of Civil Engineers, because the figures were given in feet and Fahrenheit degrees. No doubt the normal temperature would have been 95 degrees Fahrenheit at the bottom of the shaft, whereas it was reduced by ventilation to 59, the heat at the face of the workings being 77 degrees. Mr. Daglish had caught him tripping about water; speaking of comparatively no water, he was only speaking of one condition. For instance, if they were sinking in the Weald, where it was very clayey, they would get practically no water, but if they were getting through Chalk they were likely to do so whatever the conditions of the Chalk were. Still it was perfectly true there would be no difficulty whatever in coping with the water in sinking a shaft, and when once it was tubbed back it would not sink to the workings, because it would be stopped by the impervious Gault. Water in wells was not got so much from the shaft as from headings; five-sixths of the water got from the waterworks was got from headings. In sinking a shaft for mining purposes they would go right through the Chalk, and could pump out what water came. With regard to Mr. Walker's question as to coal at Dover, it was originally stated that it was horizontal, but Prof. Boyd Dawkins says there is very little warrant for that statement, like many others at first made. It was said, for instance, at first, that the Lias was found there, and that the strata were probably of the same nature as those found underlying the Great

Oolite in the North of France. As regards the cores of the London borings, most of the specimens were in the museum at Jermyn Street, and those interested in the subject would have the opportunity of seeing them the next day, when Mr. Brown would conduct the party over the museum. In speaking of likely places, he had in his notes Kingsclere, but forgot to mention it. As Mr. Whitaker observed, farther to the west was certainly a good place. He certainly hoped the Chatham boring would be continued, though he did not think it likely that the Government would be induced to do it, at any rate the Admiralty, who put it down for water, would not. The Treasury might, and no doubt if institutions of this kind would send memorials up they would have considerable weight.

Mr. JOHN DAGLISH proposed a vote of thanks to Mr. Topley for his very valuable paper on a subject full of interest to everyone in England, and more particularly to an institution of the character of this Institute. The paper had been in itself interesting on account of the statement of facts in regard to Dover, but it extended also to the Belgian coal-field, on which it had given much valuable information, and it also extended to the Bristol coal-field on the other side. He might add that the fact of receiving this paper was an indication of the benefit of the Federation. They could hardly have hoped that Mr. Topley would have come into the colliery districts to give his paper, and the very fact of obtaining it was a distinctive mark of their meeting in London.

Mr. T. J. BEWICK expressed pleasure in seconding the vote of thanks, and also in endorsing Mr. Daglish's remarks. He had the privilege a week ago of hearing Mr. Whitaker's paper read, and they now had the whole question brought before them. The recent discovery at Dover had put such a large amount of interest into the matter that not only engineers but Englishmen generally were extremely interested in the result of the discoveries there; he understood further investigations were to be made, and as the deepening of the hole was to be done by means of the diamond drill excellent cores would be got, and if they did not determine the dip of the measures they would at any rate give a better idea of the character of the strata than what has been obtained. He believed it was a fact that to the north of Battle and towards London there were landed proprietors who were going to make borings with a view to the discovery of coal. Assuming these went on, as he believed they would most likely do, there would be in a very short time considerable light thrown on the subject in just that part, to judge from the map, that seemed to want development.

The PRESIDENT said that he was sure the members present had all been pleased, as he was, to have had the opportunity of hearing Mr. Topley's paper, and the remarks of the other gentlemen who had so kindly attended. A vote of thanks had been proposed and seconded to these gentlemen, and he was quite sure the meeting would most unanimously endorse it.

The vote of thanks was carried with acclamation.

Mr. TOPLEY acknowledged the vote. He desired to thank the members for the way they had listened to him; he had been long and tedious, and the subject had been treated inadequately in many respects on account of the time.

The PRESIDENT said it would be understood that at a future meeting—whether at Edinburgh or elsewhere—this paper would be again open for discussion and perhaps by that time Mr. Bewick's prophesied information might be ready.

APPENDICES.

I.—BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEAR 1889.

By M. Walton Brown.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of the Glasgow and Kew Observatories, and give some idea of the variations of temperature and of atmospheric pressure in the intervening districts in which the mining operations of this country are chiefly carried on.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level by the addition of ·150 inch to each reading, and the barometer readings at both Observatories are reduced to 32 degs. Fahr.

The fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are printed upon the diagrams recording the Meteorological Observations.

JANUARY, 1889.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	30·114	30·188	30·215	30·290	32·3	24·8	N	1	30·014	30·184	30·280	30·354	41·0	29·0	S
2	30·346	30·448	30·521	30·610	37·4	22·9	N	2	30·391	30·463	30·499	30·544	35·1	26·6	SSE
3	30·640	30·711	30·700	30·685	36·2	29·0	NNE	3	30·511	30·509	30·482	30·478	42·0	34·9	SW
4	30·687	30·671	30·598	30·543	34·0	26·4	NNE	4	30·444	30·421	30·365	30·310	42·6	40·7	SW
5	30·473	30·424	30·319	30·232	30·1	23·9	NNE	5	30·290	30·141	30·054	29·957	42·3	39·5	SW
6	30·145	30·117	30·033	30·000	29·5	19·7	NNE	6	29·896	29·938	29·928	29·931	42·3	32·8	NW
7	29·988	30·035	30·011	30·019	32·0	24·3	WNW	7	29·882	29·868	29·792	29·729	41·4	29·5	WSW
8	29·937	29·885	29·755	29·694	44·3	27·0	SE	8	29·609	29·535	29·449	29·391	44·1	41·0	S
9	29·578	29·479	29·410	29·256	47·1	40·5	SW	9	29·277	29·138	29·001	29·193	45·0	37·0	SE
10	29·263	29·378	29·480	29·565	40·4	37·2	NW	10	29·838	29·466	29·565	29·648	38·6	32·3	NW
11	29·660	29·669	29·548	29·425	41·2	34·3	NE	11	29·645	29·576	29·455	29·475	40·3	33·5	SE
12	29·374	29·420	29·504	29·678	36·2	31·3	N	12	29·531	29·686	29·787	29·889	39·0	35·6	E
13	29·793	29·943	30·026	30·106	38·8	33·8	N	13	29·990	30·095	30·134	30·179	38·2	35·2	ENE
14	30·144	30·194	30·199	30·208	39·0	37·0	N	14	30·150	30·134	30·076	30·032	40·8	36·3	SSE
15	30·181	30·168	30·096	30·013	37·1	34·6	SSE	15	29·957	29·893	29·812	29·768	42·0	39·5	SSE
16	29·943	29·939	29·966	30·066	35·1	33·3	SE	16	29·735	29·745	29·764	29·815	41·5	38·9	SE
17	30·158	30·272	30·364	30·420	40·4	34·8	SW	17	29·955	30·056	30·040	29·994	46·4	35·8	SW
18	30·435	30·429	30·343	30·291	49·9	33·0	SW	18	29·945	29·906	29·845	30·039	51·7	39·8	SW
19	30·315	30·356	30·306	30·286	47·6	36·0	W	19	30·018	30·040	30·116	30·113	44·3	39·1	WNW
20	30·239	30·202	30·225	30·300	43·3	30·1	WSW	20	30·128	30·230	30·210	30·221	43·6	35·3	WNW
21	30·296	30·306	30·265	30·326	42·1	29·1	W	21	30·249	30·329	30·404	30·494	45·9	35·5	WNW
22	30·343	30·416	30·412	30·445	40·5	35·9	NNE	22	30·489	30·507	30·424	30·404	40·2	31·1	WNW
23	30·431	30·480	30·454	30·482	40·1	30·8	NW	23	30·402	30·422	30·384	30·415	46·2	32·3	WSW
24	30·453	30·468	30·465	30·484	42·2	32·8	SSW	24	30·397	30·383	30·349	30·337	46·7	42·7	W
25	30·457	30·458	30·389	30·400	43·8	40·2	W	25	30·270	30·227	30·154	30·142	47·4	43·6	WSW
26	30·366	30·399	30·353	30·367	49·5	41·9	W	26	30·141	30·147	30·223	30·383	47·5	33·0	NW
27	30·476	30·609	30·608	30·605	44·3	28·5	NNE	27	30·463	30·489	30·371	30·254	42·0	28·8	SSW
28	30·492	30·460	30·362	30·288	48·1	31·9	SW	28	30·175	30·138	30·039	29·877	45·9	41·9	WSW
29	30·090	29·905	29·833	30·027	48·1	35·0	SW	29	29·568	29·413	29·726	29·745	46·2	37·0	NW
30	30·032	29·944	29·790	29·900	47·0	32·3	SW	30	29·513	29·375	29·604	29·686	48·3	39·8	WNW
31	29·960	29·915	29·802	29·838	53·0	40·8	W	31	29·562	29·460	29·453	29·584	50·7	42·8	WSW

FEBRUARY, 1889.

1	29·816	29·772	29·605	29·591	55·8	47·3	SW	1	29·559	29·319	29·225	29·213	51·1	36·3	SW
2	29·647	29·705	29·634	29·548	47·3	33·5	W	2	29·178	29·207	29·156	29·071	38·5	31·0	W
3	29·311	29·228	29·151	29·221	42·1	32·9	W	3	28·996	29·101	29·464	29·794	43·0	34·6	NNW
4	29·666	29·861	30·091	30·244	40·1	30·6	NE	4	30·090	30·280	30·337	30·306	40·1	33·2	NW
5	30·275	30·263	30·147	30·070	39·6	28·0	W	5	30·146	29·994	29·921	29·908	44·4	33·1	WSW
6	30·011	29·989	29·923	29·812	43·3	38·8	WNW	6	29·878	29·883	29·816	29·655	42·4	33·4	W
7	29·485	29·625	29·884	29·988	45·3	40·9	N	7	29·680	29·892	29·885	29·664	37·9	28·9	NW
8	29·820	29·520	29·347	29·367	48·3	30·1	WSW	8	29·230	29·152	29·114	29·338	43·5	31·5	WNW
9	29·452	29·568	29·630	29·758	36·9	28·1	NW	9	29·478	29·639	29·709	29·738	32·2	26·4	NNW
10	29·802	29·742	29·424	29·133	33·0	23·9	SW	10	29·675	29·545	29·358	29·348	29·5	25·0	NW
11	29·140	29·473	29·664	29·853	33·3	26·6	N	11	29·465	29·661	29·802	30·016	35·6	26·4	N
12	30·020	30·127	30·193	30·315	35·8	21·0	NW	12	30·107	30·183	30·141	30·068	37·8	28·6	WSW
13	30·279	30·178	29·966	29·757	41·1	15·1	SSW	13	29·805	29·656	29·538	29·102	47·4	34·1	W
14	29·522	29·488	29·377	29·440	48·9	39·2	W	14	29·178	29·235	29·190	29·126	47·0	34·0	WNW
15	29·476	29·652	29·860	30·107	44·7	31·8	NW	15	29·350	29·665	29·882	30·020	40·5	30·1	NW
16	30·198	30·173	29·989	30·017	44·8	29·6	SSW	16	29·931	29·613	29·600	29·742	47·9	30·3	WSW
17	30·080	30·194	30·236	30·340	55·6	41·0	W	17	29·865	29·935	29·971	30·065	50·0	42·5	WSW
18	30·497	30·436	30·421	30·385	52·5	40·1	W	18	30·098	30·104	30·040	29·971	50·2	45·0	SW
19	30·344	30·400	30·362	30·334	49·1	42·5	W	19	30·080	30·190	30·226	30·155	46·3	39·5	WNW
20	30·201	30·050	29·915	29·945	49·2	39·7	NW	20	29·978	29·881	29·904	30·011	47·3	39·0	WNW
21	30·012	30·130	30·176	30·207	41·2	34·9	N	21	30·121	30·237	30·251	30·254	42·8	36·0	N
22	30·175	30·161	30·103	30·081	41·0	32·7	NNW	22	30·219	30·205	30·138	30·159	41·2	36·0	WSW
23	30·094	30·158	30·191	30·235	37·3	30·6	NNE	23	30·213	30·296	30·341	30·406	40·1	32·8	ENE
24	30·236	30·207	30·124	30·123	38·3	31·8	N	24	30·359	30·335	30·271	30·271	41·3	29·0	NNE
25	30·044	30·001	29·883	29·837	38·1	31·9	N	25	30·175	30·064	29·861	29·777	38·9	34·1	W
26	29·793	29·799	29·746	29·702	35·4	29·1	NE	26	29·780	29·866	29·839	29·784	38·4	32·1	E
27	29·620	29·585	29·553	29·596	37·2	31·9	ENE	27	29·702	29·680	29·650	29·686	37·9	31·8	ENE
28	29·612	29·684	29·733	29·798	35·1	30·5	NE	28	29·739	29·821	29·865	29·963	36·4	31·4	ESE

MARCH, 1889.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·805	29·857	29·857	29·905	34·9	30·8	NE	1	29·969	29·989	29·967	29·976	35·3	29·8	E
2	29·905	29·938	29·926	29·957	33·8	29·2	NNE	2	29·947	29·963	29·935	29·955	35·4	29·0	ENE
3	29·954	29·991	29·985	30·021	36·0	23·5	SE	3	29·941	29·953	29·921	29·948	34 9	27·1	SE
4	30·020	30·053	30·008	30·040	37·2	20·9	SE	4	29·941	29·950	29·921	29·946	35·0	25·1	SE
5	30·056	30·145	30·148	30·184	38·7	28·0	S	5	29·929	29·925	29·863	29·870	36·5	30·6	ESE
6	30·161	30·112	29·993	29·894	45·2	25·9	SSW	6	29·771	29·663	29·567	29·521	41·0	33·3	SSW
7	29·669	29·399	29·318	29·327	49·0	35·9	S	7	29·442	29·406	29·318	29·280	38·1	33·4	ESE
8	29·291	29·264	29·147	28·991	52·8	40·2	S	8	29·266	29·294	29·258	29·273	43·2	31·6	WSW
9	29·323	29·534	29·589	29·690	49·7	29·7	W	9	29·270	29·339	29·370	29·376	44·1	33·4	W
10	29·710	29·722	29·708	29·761	43·9	40·1	NE	10	29·480	29·588	29·675	29·816	45·2	33·7	WNW
11	29·808	29·940	30·036	30·193	44·1	32·8	N	11	29·905	30·035	30·060	30·080	44·1	30·0	WNW
12	30·252	30·275	30·235	30·257	48 1	29·7	SW	12	30·058	30·094	30·088	30·012	49·4	39·1	W
13	30·223	30·158	30·164	30·258	53·2	47·1	NW	13	29·998	30·097	30·163	30·276	51·5	40·0	W
14	30·302	30·345	30·293	30·371	48·2	38·2	N	14	30·298	30·310	30·291	30·380	49·6	37·6	W
15	30·440	30·551	30·558	30·580	38·3	28·9	NE	15	30·423	30·455	30·414	30·385	43·1	37·5	SW
16	30·523	30·454	30·312	30·276	49·5	28·1	SW	16	30·290	30·208	30·186	30·176	50·8	41·2	WNW
17	30·229	30·232	30·143	30·089	52·4	38·2	WNW	17	30·101	30·039	29·971	29·898	48·5	38·9	WSW
18	29·993	29·913	29·740	29·602	48·1	41·9	SSW	18	29·773	29·704	29·585	29·487	42·0	37·2	NE
19	29·428	29·359	29·201	29·003	53·6	38·0	SSW	19	29·342	29 237	29·092	28·992	44·4	39·0	ESE
20	28·967	28·981	28·952	29·013	49·8	40·2	SSW	20	28·926	29·026	29·210	29·426	41·0	35·0	NE
21	29·117	29·313	29·588	29·847	40·8	34·3	N	21	29·578	29·748	29·844	29·947	39·9	32·1	NE
22	29·989	30·115	30·143	30·211	45·0	32·8	N	22	29·965	29·969	29·993	30·008	48·7	31·8	WNW
23	30·243	30·286	30·244	30·255	51·0	30·9	W	23	29·912	29·850	29·791	29·834	47·5	41·5	SW
24	30·217	30·208	30·179	30·198	58·3	44·0	WSW	24	29·834	29·835	29·876	29·824	51·0	47·1	WSW
25	30·101	29·994	29·895	29·947	57·6	43·0	SW	25	29·648	29·706	29·697	29·692	50·0	38 9	W
26	29·924	29·929	29·993	30·105	47·8	39·1	NW	26	29·764	29·924	30·029	30·183	45·1	34·4	NW
27	30·188	30·287	30·313	30·432	47·0	32·1	N	27	30·275	30·349	30·323	30·317	44·7	29·3	W
28	30·458	30·468	30·403	30·392	50·8	27·0	W	28	30·257	30·229	30·223	30·257	48·6	37·9	SW
29	30·331	30·327	30·292	30·268	57·8	43·7	NW	29	30·252	30·234	30·187	30·127	51·9	45·3	W
30	30·190	30·133	30·022	29·965	54·0	43·7	W	30	30·028	29·953	29·936	29·908	50·2	40·2	WNW
31	29·910	29·873	29·830	29·894	50·9	39·1	NW	31	29·833	29·833	29·829	29·880	51·3	38·7	NW

APRIL, 1889.

1	29·942	29·963	29·891	29·866	52·5	34·2	WNW	1	29·853	29·751	29·727	29·787	47·0	38·0	WNW
2	29·852	29·910	29·878	29·862	48·8	40·9	NW	2	29·839	29·866	29·844	29·866	44·0	35·7	WNW
3	29·854	29·846	29·719	29·499	43·3	36·8	SW	3	29·793	29·672	29·439	29·213	39·0	36·2	SSE
4	29·332	29·205	29·161	29·256	50·6	42·0	S	4	29·135	29·188	29·348	29·488	40·1	35·1	ENE
5	29·327	29·396	29·397	29·451	53·6	38·8	SE	5	29·527	29·532	29·544	29·624	41·6	35·9	E
6	29·456	29·504	29·451	29·430	50·1	40·0	NE	6	29·502	29·594	29·530	29·540	43·0	35·2	E
7	29·351	29·356	29·351	29·398	50·8	37·3	E	7	29·534	29·547	29·561	29·564	43·4	36·9	E
8	29·353	29·329	29·254	29·254	54·4	42·4	ENE	8	29·460	29·458	29·438	29·484	44·6	36·5	E
9	29·259	29·326	29·360	29·428	48·0	42·6	NE	9	29·488	29·504	29·499	29·536	43·6	36·2	ESE
10	29·439	29·487	29·474	29·489	44·4	40·4	E	10	29·527	29·580	29·591	29·614	41·6	36·8	E
11	29·461	29·472	29·493	29·545	49·1	36·0	SE	11	29·590	29·582	29·573	29·607	42·3	38·3	NE
12	29·511	29·595	29·593	29·642	51·0	35·0	NE	12	29·638	29·759	29·812	29·881	43·8	38·3	ENE
13	29·652	29·704	29·693	29·705	46·1	39·6	N	13	29·880	29·880	29·858	29·888	47·0	37·4	NE
14	29·677	29·719	29·767	29·869	43·6	37·0	N	14	29·887	29·906	29·875	29·906	51·9	32·4	W
15	29·897	29·931	29·896	29·954	48·2	36·0	N	15	29·901	29·923	29·941	29·971	51·0	36·0	ENE
16	29·956	29·962	29·935	29·957	48·5	33·6	N	16	29·951	29·962	29·921	29·907	51·6	39·0	WNW
17	29·926	29·947	29·935	30·010	55·0	39·8	NW	17	29·891	29·921	29·955	29·983	54·2	42·0	WNW
18	30·046	30·112	30·109	30·144	61·9	48·2	N	18	29·995	30·026	29·984	29·957	49·5	45·4	WSW
19	30·169	30·218	30·182	30·193	61·9	43·8	W	19	29·924	29·927	29·894	29·855	56·9	46·2	SW
20	30·100	30·035	29·993	29·987	58·8	45·6	SW	20	29·712	29·700	29·649	29·534	53·6	44·7	WSW
21	29·874	29·795	29·684	29·755	55·0	42·0	SSW	21	29·388	29·326	29·317	29·365	49·2	41·3	SW
22	29·766	29·797	29·785	29·852	55·0	40·9	W	22	29·406	29·621	29·659	29·658	48·8	40·0	W
23	29·843	29·751	29·558	29·542	53·2	37·0	SW	23	29·452	29·284	29·261	29·303	50·3	41·5	W
24	29·444	29·434	29·461	29·563	49·1	42·6	NW	24	29·396	29·567	29·658	29·802	50·0	38·8	NNE
25	29·606	29·731	29·870	29·969	51·1	37·3	N	25	29·882	29·945	29·926	29·939	53·2	42·2	ENE
26	29·991	29·996	29·957	29·976	58·1	34·1	SW	26	29·893	29·814	29·724	29·693	50·9	37·7	SSE
27	29·945	29·978	29·925	29·928	60·0	45·2	WSW	27	29·738	29·814	29·802	29·778	55·0	41·4	SW
28	29·821	29·749	29·678	29·765	57·3	42·2	S	28	29·721	29·620	29·489	29·510	56·0	41·5	SE
29	29·815	29·855	29·834	29·804	57·3	38·7	S	29	29·549	29·652	29·691	29·758	53·1	40·9	SSW
30	29·650	29·538	29·483	29·574	60·9	44·1	ESE	30	29·752	29·743	29·647	29·523	51·9	40·7	ENE

MAY, 1889.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·612	29·694	29·706	29·704	54·2	41·9	SE	1	29·441	29·481	29·574	29·662	54·9	43·4	SE
2	29·679	29·718	29·789	29·905	58·3	42·0	E	2	29·653	29·646	29·653	29·713	58·2	42·0	S
3	29·937	29·953	29·953	29·970	60·9	44·2	S	3	29·723	29·727	29·731	29·795	51·3	46·0	SSE
4	29·940	29·916	29·875	29·890	71·9	48·7	SE	4	29·831	29·853	29·838	29·677	61·7	50·2	S
5	29·847	29·821	29·761	29·789	73·4	52·0	E	5	29·860	29·864	29·836	29·869	56·3	47·0	ENE
6	29·771	29·773	29·738	29·775	71·9	49·9	E	6	29·887	29·906	29·850	29·857	60·2	44·9	ENE
7	29·782	29·794	29·774	29·797	64·0	51·4	S	7	29·806	29·745	29·667	29·672	58·2	46·3	ENE
8	29·789	29·848	29·825	29·827	63·0	48·0	S	8	29·639	29·662	29·680	29·721	58·2	47·0	W
9	29·722	29·680	29·608	29·659	71·6	50·7	E	9	29·721	29·748	29·682	29·698	58·0	49·2	E
10	29·668	29·750	29·781	29·802	61·3	51·0	SW	10	29·640	29·619	29·678	29·799	55·4	46·2	ENE
11	29·760	29·765	29 769	29·769	55·2	48·4	NW	11	29·824	29·812	29·801	29·887	56·5	47·9	ENE
12	29·744	29·777	29·800	29·828	52·1	47·3	WSW	12	29·896	29·891	29·881	29·917	62·7	48·0	ENE
13	29·825	29·869	29·860	29·880	58·1	50·0	SSW	13	29·916	29·937	29·872	29·878	63·6	46·1	E
14	29·834	29·835	29·779	29·798	59·6	48·9	N	14	29·825	29·794	29·734	29·747	53·3	45·2	ESE
15	29·775	29·805	29·819	29·892	62·7	46·8	N	15	29·716	29·764	29·786	29·864	55·5	45·0	ENE
16	29·942	29·971	29·938	29·960	69·7	46·1	NE	16	29·922	29·956	29·937	29·963	59·5	45·0	SSE
17	29·937	29·921	29·857	29·888	63·4	47·0	NE	17	29·972	29·997	29·942	29·913	61·7	46·1	SSE
18	29·903	29 934	29·905	29·913	63·4	47·2	SW	18	29·856	29·844	29·838	29·847	63·3	47·8	ESE
19	29·902	29·906	29·898	29·949	59·8	46·1	WSW	19	29·857	29·867	29·881	29·945	67·0	47·6	N
20	29·969	30·042	30·054	30·077	62·0	51·4	N	20	29·971	30·014	30·008	30·051	70·1	47·6	SW
21	30·068	30·073	30·057	30·066	66·9	50·8	NNE	21	30·052	30·046	30·000	29·979	72·1	51·9	WNW
22	30·024	29·978	29·892	29·896	76·2	48·3	NNE	22	29·918	29·883	29·836	29·842	69·8	53·6	SSW
23	29·848	29·815	29·731	29·718	77·2	53·3	S	23	29·787	29·771	29·706	29·643	66·9	53·7	SW
24	29·658	29·610	29·501	29·494	77·9	52·1	SE	24	29·557	29·519	29·508	29·547	60·3	48·5	SW
25	29·457	29·521	29·539	29·599	68·0	54·2	WNW	25	29·518	29·545	29·551	29·603	60·0	45·1	WNW
26	29·581	29·631	29·656	29·699	57·5	52·0	NNE	26	29·621	29·681	29·695	29·775	64·7	43·4	NE
27	29·669	29·704	29·672	29·671	57·7	51·2	NNE	27	29·798	29·775	29·674	29·646	65·6	47·8	NE
28	29·639	29·664	29·666	29·659	61·2	51·9	SSW	28	29·555	29·459	29·385	29·409	53·6	49·0	E
29	29·659	29·673	29·687	29·772	61·4	47·4	SW	29	29·403	29·414	29·439	29·483	60·0	47·7	SW
30	29·793	29·840	29·820	29·835	61·0	47·3	S	30	29·481	29·541	29·568	29·582	59·2	46·7	SW
31	29·817	29·838	29·834	29·909	63·4	48·0	S	31	29·504	29·504	29·520	29·572	58·6	47·6	SW

JUNE, 1889.

1	29·940	29·941	29·884	29·863	71·0	45·8	S	1	29·630	29·701	29·712	29·751	60·0	51·0	SSE
2	29·755	29·670	29·660	29·708	78·3	56·2	S	2	29·751	29·713	29 613	29·658	62·2	53·0	E
3	29·736	29·827	29·945	30·069	70·5	53·1	WSW	3	29·673	29·708	29·764	29·855	64·0	53·4	SW
4	30·146	30·245	30·284	30·345	73·2	51·1	WNW	4	29·931	30·071	30·213	30·341	65·2	50·0	SW
5	30·366	30·375	30·278	30·241	70·0	53·7	NNE	5	30·398	30 434	30·381	30·353	68·2	46·8	W
6	30·176	30·114	29·995	29·978	79·2	54·2	N	6	30·318	30·220	30·102	30·080	67·0	50·4	E
7	29·942	29·956	29·937	29·998	75·5	56·2	N	7	30·087	30·116	30·076	30·073	66·8	49·1	NE
8	29·954	29·929	29·836	29·800	59·6	53·9	N	8	29·992	29·918	29·823	29·766	61·1	46·4	WSW
9	29·698	29·665	29·614	29·611	58·4	53·1	N	9	29·714	29·752	29·748	29·855	59·0	48·6	E
10	29·597	29·667	29·714	29·793	53·7	49·3	NNE	10	29·901	29·937	29·922	29·948	62·2	45·5	ENE
11	29·787	29·838	29·852	29·890	59·0	49·4	N	11	29·925	29·885	29·810	29·799	64·0	42·6	WSW
12	29·807	29·934	29·911	29·936	65·4	53·6	NW	12	29·786	29·817	29·821	29·843	62·6	50·5	WSW
13	29·916	29·921	29·872	29·916	71·2	55·1	SW	13	29·802	29·771	29·724	29·735	65·0	51·8	SSW
14	29·936	29·965	29·941	29·948	63·6	51·9	SW	14	29·756	29·797	29·788	29·838	62·2	50·0	SW
15	29·926	29·951	29·942	29·983	66·3	54·8	SW	15	29·852	29·910	29·923	29·985	64·4	47·0	SW
16	30·016	30·058	30·055	30·108	68·9	51·9	NNE	16	30·007	30·052	30·075	30·105	63·4	49·8	W
17	30·139	30·163	30·171	30·209	66·1	49·0	NE	17	30·136	30·155	30·158	30·179	69·0	47·2	WNW
18	30·201	30·202	30·138	30·143	63·1	49·7	NE	18	30·205	30·202	30·151	30·174	70·5	46·6	NE
19	30·098	30·088	30·039	30·076	64·9	48·1	NE	19	30·173	30·175	30·144	30·170	66·7	51·0	E
20	30·054	30·060	29·989	30·017	70·9	53·1	NE	20	30·158	30·156	30·107	30·109	66·8	51·8	E
21	30·021	30·033	30·001	30·046	71·2	54·3	NE	21	30·116	30·108	30·031	30·034	76·0	51·0	ENE
22	30·046	30·077	30·006	30·048	73·9	51·9	N	22	30·064	30·065	30·053	30·127	77·2	48·5	NW
23	30·063	30·045	29·980	30·016	67·3	51·5	NNW	23	30·123	30·113	30·058	30·052	62·3	49·9	E
24	29·992	30·013	29·980	30·011	65·3	51·8	NNE	24	30·042	30·047	30·004	30·049	67·2	48·9	ENE
25	30·032	30·054	30·030	30·082	74·5	53·0	ESE	25	30·061	30·083	30·029	30·056	71·5	52·2	NE
26	30·083	30·076	30·020	30·037	75·7	51·0	NNE	26	30·047	30·036	29·976	29·986	72·7	52·1	SSW
27	30·006	29·995	29·965	30·023	78·0	55·1	N	27	29·981	30·011	30·009	30·022	66·6	51·1	W
28	30·017	30·035	30·021	30·092	79·0	53·9	SE	28	29·990	29·990	30·012	30·075	67·2	48·7	WSW
29	30·125	30·165	30·161	30·242	75·7	55·4	NW	29	30·114	30·157	30·147	30·132	64·8	50·1	SW
30	30·261	30·286	30·251	30·297	74·8	56·4	W	30	30·100	30·153	30·228	30·320	63·0	51·5	WNW

JULY, 1889.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	30·348	30·361	30·349	30·382	70·0	54·1	W	1	30·353	30·385	30·386	30·396	66·0	50·2	WNW
2	30·366	30·361	30·310	30·296	65·6	52·9	NNE	2	30·379	30·379	30·354	30·353	69·6	54·4	ENE
3	30·273	30·243	30·191	30·183	62·2	54·5	NE	3	30·346	30·317	30·255	30·251	69·6	53·2	ENE
4	30·157	30·139	30·103	30·143	69·2	55·8	NE	4	30·239	30·224	30·187	30·221	68·0	53·0	ESE
5	30·144	30·157	30·107	30·144	75·8	54·9	E	5	30·216	30·231	30·171	30·154	69·0	55·0	NW
6	30·112	30·070	29·930	29·859	76·7	50·6	WSW	6	30·067	29·955	29·824	29·719	68·6	54·3	W
7	29·765	29·718	29·682	29·758	70·3	57·1	W	7	29·641	29·642	29·634	29·632	59·0	45·0	WNW
8	29·749	29·766	29·768	29·806	62·7	54·1	SE	8	29·641	29·657	29·676	29·735	60·7	42·0	WNW
9	29·816	29·833	29·768	29·719	71·7	57·3	S	9	29·742	29·774	29·710	29·712	65·8	47·8	E
10	29·670	29·665	29·541	29·776	71·1	57·8	SSE	10	29·617	29·594	29·587	29·684	57·2	51·9	NE
11	29·870	29·955	29·956	29·986	70·4	52·3	SW	11	29·726	29·820	29·895	29·967	54·2	49·0	NE
12	29·960	29·958	29·940	29·960	70·9	58·0	E	12	29·980	30·017	29·991	30·008	62·1	48·4	E
13	29·926	29·883	29·826	29·823	70·3	59·9	S	13	29·977	29·944	29·851	29·853	67·0	50·0	ENE
14	29·779	29·795	29·846	29·904	67·4	57·3	NE	14	29·826	29·807	29·669	29·742	60·1	47·0	W
15	29·887	29·883	29·847	29·838	65·9	52·1	SW	15	29·668	29·654	29·608	29·632	60·2	47·7	WSW
16	29·831	29·835	29·806	29·786	65·9	50·0	WSW	16	29·649	29·687	29·723	29·758	63·4	44·9	NNW
17	29·716	29·965	29·803	29·865	65·2	48·7	WNW	17	29·765	29·813	29·815	29·847	63·1	48·8	N
18	29·899	29·929	29·902	29·925	67·9	52·2	SW	18	29·845	29·853	29·830	29·815	60·9	49·0	W
19	29·911	29·908	29·845	29·842	68·1	47·0	SW	19	29·749	29·734	29·724	29·721	59·6	50·1	W
20	29·830	29·768	29·692	29·678	65·2	49·1	S	20	29·680	29·636	29·558	29·503	57·7	50·5	E
21	29·651	29·600	29·590	29·663	65·9	55·8	SW	21	29·435	29·402	29·400	29·547	65·2	49·5	W
22	29·781	29·874	29·864	29·846	65·9	50·8	SW	22	29·592	29·618	29·615	29·620	61·4	47·2	SW
23	29·788	29·774	29·731	29·730	63·9	49·2	SW	23	29·603	29·647	29·659	29·703	59·9	49·9	N
24	29·770	29·809	29·797	29·709	62·1	47·0	SW	24	29·677	29·599	29·518	29·409	61·0	44·0	SSW
25	29·571	29·556	29·535	29·535	62·2	54·3	SW	25	29·354	29·360	29·465	29·597	59·5	50·8	NNW
26	29·553	29·655	29·702	29·767	65·9	53·4	N	26	29·624	29·674	29·705	29·793	68·1	50·0	NW
27	29·798	29·875	29·916	29·990	65·9	54·0	NNW	27	29·829	29·888	29·895	29·935	69·6	48·2	WNW
28	30·008	30·040	30·024	30·056	71·1	51·3	W	28	29·914	29·922	29·924	29·970	61·2	51·1	WSW
29	30·048	30·081	30·085	30·106	74·0	57·1	NW	29	29·971	30·019	30·035	30·078	67·4	55·0	W
30	30·104	30·118	30·079	30·106	75·1	55·7	S	30	30·063	30·068	30·024	30·021	71·7	54·8	SE
31	30·105	30·104	30·043	30·038	76·1	55·3	SE	31	29·995	29·967	29·917	29·907	74·9	57·8	SSW

AUGUST, 1889.

1	29·973	29·921	29·853	29·897	80·2	57·9	S	1	29·855	29·839	29·785	29·744	68·8	59·2	WSW
2	29·901	29·949	29·959	29·961	71·1	57·0	SW	2	29·678	29·682	29·695	29·657	65·0	55·3	SW
3	29·883	29·836	29·822	29·882	68·2	59·6	SW	3	29·566	29·507	29·556	29·662	61·5	54·3	ENE
4	29·920	29·961	29·902	29·861	71·0	56·0	SW	4	29·742	29·807	29·782	29·758	65·0	53·1	SW
5	29·760	29·687	20·647	29·720	68·8	55·7	SW	5	29·652	29·555	29·476	29·422	56·4	52·7	ENE
6	29·704	29·703	29·723	29·801	66·4	53·1	SW	6	29·367	29·415	29·517	29·636	61·0	52·9	NNE
7	29·846	29·958	29·991	30·080	68·8	52·3	W	7	29·707	29·814	29·865	29·944	66·3	52·8	WNW
8	30·093	30·086	30·014	30·013	67·4	49·2	SW	8	29·960	29·965	29·883	29·851	65·2	51·7	ENE
9	29·965	29·908	29·819	29·769	63·2	52·6	S	9	29·719	29·660	29·653	29·636	63·3	51·1	W
10	29·772	29·750	29·657	29·600	67·3	50·8	SW	10	29·587	29·549	29·528	29·526	62·2	47·3	NNE
11	29·512	29·489	29·511	29·602	65·1	51·1	SW	11	29·513	29·564	29·629	29·703	59·0	52·3	NE
12	29·622	29·699	29·781	29·858	60·6	50·3	NW	12	29·755	29·803	29·810	29·856	60·6	51·2	NW
13	29·926	29·985	29·992	30·032	62·6	53·0	NW	13	29·856	29·890	29·900	29·885	61·0	48·5	WNW
14	30·004	29·950	29·804	29·690	64·2	52·7	SW	14	29·763	29·632	29·563	29·611	59·6	49·6	NE
15	29·734	29·818	29·827	29·893	69·8	57·3	WSW	15	29·614	29·627	29·648	29·749	63·1	51·9	SW
16	29·951	29·985	29·931	29·886	72·4	56·1	SW	16	29·768	29·775	29·633	29·382	60·8	50·6	SW
17	29·792	29·765	29·800	29·914	70·1	52·3	SW	17	29·397	29·479	29·553	29·595	61·0	51·9	WSW
18	29·946	29·985	29·939	29·916	69·0	50·0	SSW	18	29·586	29·662	29·718	29·740	61·5	52·4	WSW
19	29·798	29·658	29·479	29·375	72·1	51·2	NNE	19	29·684	29·620	29·490	29·347	62·0	52·5	SSW
20	29·200	29·295	29·502	29·622	64·8	55·7	WSW	20	29·164	29·130	29·167	29·270	58·1	51·0	WNW
21	29·561	29·483	29·272	29·234	64·4	54·7	S	21	29·274	29·255	29·161	29·139	61·5	49·4	WSW
22	29·290	29·488	29·589	29·775	61·9	51·2	WSW	22	29·187	29·378	29·513	29·677	61·1	48·0	WNW
23	29·870	29·946	29·929	29·920	61·3	49·8	W	23	29·654	29·670	29·650	29·670	59·1	48·5	W
24	29·854	29·815	29·784	29·818	63·1	49·4	W	24	29·659	29·719	29·715	29·730	59·3	44·6	WNW
25	29·829	29·866	29·862	29·931	62·9	45·1	NW	25	29·674	29·733	29·768	29·878	60·6	47·9	W
26	29·977	30·030	30·076	30·150	61·1	48·9	NW	26	29·921	29·966	30·003	30·009	57·1	45·1	W
27	30·182	30·232	30·219	30·238	64·9	45·3	W	27	29·986	30·030	30·011	29·946	56·3	53·3	WSW
28	30·205	30·203	30·133	30·165	67·6	50·2	SW	28	29·810	29·792	29·827	29·841	58·9	52·3	SW
29	30·159	30·190	30·135	30·159	73·3	50·1	SW	29	29·848	29·953	29·967	29·995	58·6	54·2	WSW
30	30·126	30·125	30·068	30·096	78·9	46·1	SW	30	30·003	30·057	30·077	30·135	62·0	48·0	WNW
31	30·092	30·115	30·071	30·125	75·1	50·8	N	31	30·148	30·183	30·155	30·182	63·5	43·0	WNW

SEPTEMBER, 1889.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	30·144	30·177	30·119	30·127	70·2	56·9	E	1	30·178	30·191	30·115	30·139	64·1	44·4	NE
2	30·053	30·015	29·960	29·956	68·5	57·7	E	2	30·107	30·080	30·006	30·017	61·9	52·4	NE
3	29·918	29·983	29·979	30·046	70·3	60·0	W	3	29·980	30·018	30·022	30·077	62·0	53·0	ENE
4	30·058	30·112	30·129	30·180	67·2	59·2	N	4	30·101	30·149	30·143	30·191	64·5	52·4	NNE
5	30·183	30·221	30·219	30·254	62·4	58·7	N	5	30·205	30·230	30·221	30·257	61·0	49·3	ENE
6	30·245	30·265	30·215	30·226	67·2	54·0	E	6	30·278	30·293	30·259	30·267	61·3	51·6	ENE
7	30·161	30·138	30·067	30·088	65·5	51·8	NE	7	30·242	30·223	30·126	30·119	60·4	49·2	E
8	30·060	30·080	30·061	30·106	64·6	45·9	ENE	8	30·083	30·057	29·962	29·947	65·4	50·6	ESE
9	30·099	30·128	30·120	30·174	70·7	50·0	WSW	9	29·868	29·903	29·952	29·973	63·5	55·0	SW
10	30·175	30·213	30·165	30·193	74·7	56·1	SW	10	29·988	30·033	30·007	30·005	68·0	55·5	SSW
11	30·157	30·156	30·099	30·118	76·3	51·1	S	11	29·950	29·976	29·955	29·979	62·2	57·1	SW
12	30·114	30·172	30·169	30·220	75·8	57·6	N	12	30·059	30·159	30·161	30·151	61·3	54·6	E
13	30·216	30·184	30·141	30·214	76·2	57·0	W	13	30·094	30·132	30·176	30·252	62·0	53·4	WNW
14	30·252	30·327	30·309	30·338	63·4	52·9	N	14	30·305	30·357	30·348	30·382	58·2	51·5	ENE
15	30·338	30·381	30·358	30·395	59·2	49·3	N	15	30·395	30·443	30·391	30·391	55·8	46·2	ESE
16	30·392	30·412	30·356	30·357	60·1	39·3	S	16	30·354	30·310	30·218	30·152	60·2	41·9	SSW
17	30·278	30·233	30·148	30·167	61·4	34·7	SE	17	30·047	30·013	30·017	30·047	58·4	49·6	SSW
18	30·162	30·184	30·092	30·094	64·0	37·9	SE	18	30·012	29·968	29·867	29·725	55·9	50·3	SW
19	29·956	29·870	29·710	29·661	60·8	39·2	SW	19	29·558	29·480	29·460	29·414	55·0	41·9	W
20	29·615	29·645	29·606	29·608	57·0	44·3	W	20	29·413	29·449	29·415	29·510	51·0	38·7	WNW
21	29·595	29·666	29·641	29·628	54·3	40·8	W	21	29·510	29·498	29·461	29·487	50·2	37·2	W
22	29·570	29·627	29·687	29·830	56·9	39·6	N	22	29·533	29·598	29·640	29·722	51·6	34·0	NW
23	29·869	29·892	29·800	29·699	55·7	35·5	SW	23	29·738	29·726	29·634	29·642	51·5	37·0	W
24	29·545	29·507	29·513	29·597	59·1	44·9	SSW	24	29·664	29·664	29·586	29·642	49·0	36·0	WNW
25	29·649	29·855	29·953	30·091	54·3	39·8	NW	25	29·801	29·886	29·916	29·984	53·0	36·6	NW
26	30·128	30·163	30·142	30·153	58·1	36·1	W	26	29·941	29·854	29·799	29·869	56·8	41·3	SW
27	30·123	30·111	29·985	29·928	64·9	53·5	WSW	27	29·820	29·777	29·734	29·742	55·7	49·0	WNW
28	29·854	29·821	29·761	29·766	58·6	49·0	WNW	28	29·680	29·709	29·739	29·827	44·4	45·5	WNW
29	29·775	29·786	29·786	29·818	52·2	44·8	NW	29	29·832	29·878	29·868	29·766	53·3	44·0	NW
30	29·726	29·638	29·632	29·759	54·4	46·0	NW	30	29·683	29·774	29·862	29·993	54·3	43·9	NNE

OCTOBER, 1889.

1	29·807	29·886	29·893	29·892	56·2	46·8	N	1	30·021	30·077	30·058	30·075	54·3	40·3	NE
2	29·858	29·887	29·888	29·919	57·0	47·4	NNW	2	30·017	29·960	29·846	29·806	52·1	37·7	SW
3	29·859	29·772	29·663	29·647	55·2	42·7	S	3	29·716	29·689	29·631	29·630	51·2	42·4	ENE
4	29·496	29·524	29·539	29·581	51·2	42·6	S	4	29·551	29·490	29·444	29·437	50·1	42·2	W
5	29·610	29·637	29·664	29·768	56·1	39·9	N	5	29·451	29·505	29·510	29·542	51·3	47·2	SE
6	29·808	29·857	29·811	29·726	55·9	44·6	SW	6	29·527	29·543	29·549	29·328	55·2	48·0	WSW
7	29·416	29·317	29·404	29·482	57·2	47·2	WSW	7	28·745	28·699	28·858	28·959	52·3	45·0	WNW
8	29·531	29·533	29·351	29·173	56·4	43·8	SW	8	29·049	29·089	28·982	28·915	48·0	40·5	SW
9	29·167	29·217	29·224	29·247	55·3	43·7	SSW	9	28·830	28·707	28·685	28·930	50·2	39·3	WSW
10	29·249	29·305	29·349	29·428	57·5	35·8	SW	10	28·993	29·106	29·185	29·300	53·2	42·0	WSW
11	29·416	29·435	29·461	29·528	51·3	42·9	SW	11	29·347	29·420	29·452	29·488	52·4	40·7	NW
12	29·569	29·617	29·611	29·670	55·1	39·4	SW	12	29·520	29·590	29·583	29·631	53·3	38·0	SW
13	29·714	29·794	29·816	29·880	54·3	32·0	SW	13	29·662	29·762	29·791	29·867	50·2	36·9	SSE
14	29·905	29·940	29·913	29·931	54·8	35·7	W	14	29·880	29·876	29·826	29·806	50·9	37·2	SW
15	29·906	29·901	29·852	29·832	58·6	35·7	S	15	29·737	29·680	29·574	29·599	51·2	44·4	E
16	29·762	29·722	29·687	29·689	59·1	50·5	S	16	29·594	29·644	29·647	29·676	52·8	43·7	S
17	29·715	29·771	29·769	29·774	56·1	44·4	W	17	29·681	29·701	29·657	29·633	49·5	39·0	NE
18	29·702	29·623	29·481	29·324	56·6	40·8	SE	18	29·561	29·519	29·423	29·391	52·6	42·1	ESE
19	29·150	29·092	29·231	29·258	52·6	45·8	SSW	19	29·338	29·305	29·259	29·226	53·6	45·5	ESE
20	29·130	29·189	29·216	29·269	55·8	45·0	SE	20	29·170	29·287	29·317	29·403	51·3	46·1	NE
21	29·257	29·314	29·316	29·355	50·4	41·3	E	21	29·432	29·503	29·538	29·614	51·9	46·8	ENE
22	29·316	29·376	29·402	29·449	49·5	41·9	N	22	29·644	29·711	29·755	29·798	50·4	44·3	NE
23	29·501	29·625	29·722	29·820	50·9	44·2	NNW	23	29·810	29·890	29·945	30·020	49·9	44·0	NE
24	29·895	30·004	30·045	30·112	50·6	42·8	N	24	30·044	30·119	30·140	30·206	48·5	40·4	NE
25	30·141	30·179	30·150	30·191	51·7	36·9	NE	25	30·247	30·294	30·289	30·338	46·0	38·5	ENE
26	30·158	30·127	30·034	29·953	51·3	43·9	NE	26	30·330	30·332	30·279	30·273	45·0	36·3	ENE
27	29·737	29·636	29·726	29·696	52·9	43·8	NE	27	30·184	30·118	29·992	29·950	44·6	40·6	NE
28	29·710	29·746	29·784	29·854	53·0	44·9	N	28	29·895	29·887	29·817	29·792	45·7	35·5	W
29	29·853	29·885	29·882	29·909	53·5	43·9	SE	29	29·719	29·681	29·616	29·589	49·8	35·2	SSW
30	29·898	29·909	29·809	29·699	55·9	42·9	SSW	30	29·491	29·403	29·284	29·381	53·5	42·0	S
31	29·750	29·951	29·951	29·959	51·9	42·1	W	31	29·528	29·668	29·662	29·566	50·5	41·0	SSW

NOVEMBER, 1889.

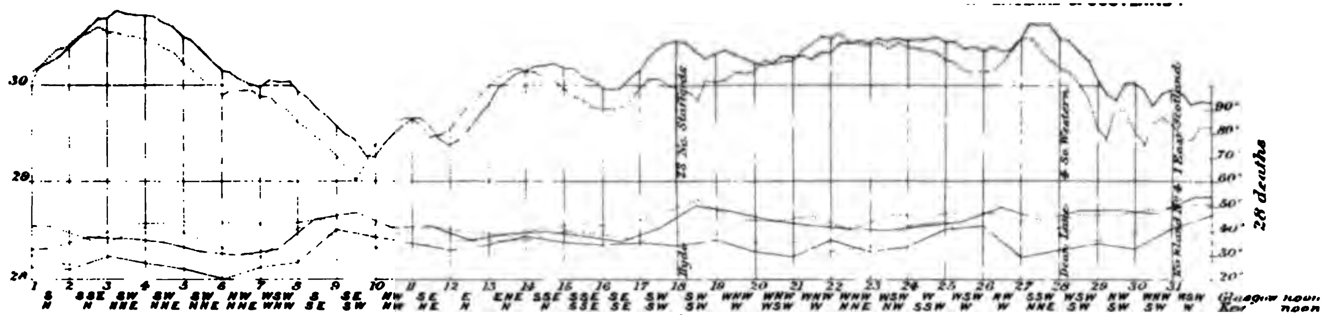
KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·757	29·616	29·686	29·770	53·5	41·1	W	1	29·289	28·817	29·067	29·291	48·9	40·9	WSW
2	29·822	29·895	29·910	29·948	51·2	39·0	W	2	29·416	29·553	29·652	29·679	48·6	39·7	W
3	29·861	29·727	29·567	29·655	52·9	40·8	S	3	29·563	29·467	29·474	29·574	46·7	41·0	ENE
4	29·719	29·698	29·814	29·870	53·7	41·8	W	4	29·623	29·704	29·733	29·746	44·7	36·4	ENE
5	29·883	29·919	29·934	30·066	46·8	31·9	WNW	5	29·647	29·684	29·766	29·889	48·4	38·0	SW
6	30·166	30·312	30·348	30·414	50·4	39·7	SW	6	30·044	30·126	30·145	30·156	51·5	43·0	WSW
7	30·422	30·487	30·452	30·471	52·4	39·0	SW	7	30·156	30·170	30·197	30·333	53·9	46·3	SW
8	30·459	30·494	30·445	30·431	57·0	42·6	NW	8	...	30·357	30·287	30·259	52·1	47·0	SW
9	30·386	30·378	30·343	30·364	54·1	42·4	NW	9	30·234	30·263	30·271	30·259	53·5	48·6	W
10	30·351	30·357	30·322	30·376	54·4	45·8	NW	10	30·259	30·307	30·319	30·324	53·4	48·9	SW
11	30·383	30·413	30·376	30·385	53·5	48·0	N	11	30·334	30·353	30·321	30·304	50·5	45·0	WSW
12	30·367	30·361	30·302	30·314	48·1	35·9	SE	12	30·262	30·247	30·218	30·258	51·5	47·7	SW
13	30·304	30·314	30·272	30·297	50·6	33·0	E	13	30·254	30·241	30·184	30·171	49·0	37·0	ESE
14	30·281	30·306	30·284	30·302	47·2	39·3	E	14	30·139	30·175	30·157	30·139	47·4	37·9	NNE
15	30·296	30·340	30·324	30·386	57·1	43·5	S	15	30·083	30·085	30·070	30·077	52·8	45·8	SSW
16	30·421	30·497	30·534	30·575	53·1	47·0	SW	16	30·227	30·446	30·513	30·566	48·0	36·0	WSW
17	30·589	30·618	30·600	30·613	51·9	48·9	N	17	30·531	30·559	30·524	30·532	44·9	32·0	NNE
18	30·603	30·633	30·611	30·644	51·0	45·6	E	18	30·499	30·511	30·474	30·478	49·1	44·8	NE
19	30·610	30·640	30·599	30·619	46·7	42·2	SSE	19	30·470	30·481	30·465	30·486	51·4	49·0	SSW
20	30·602	30·640	30·597	30·588	43·2	39·0	S	20	30·481	30·505	30·444	30·437	50·0	43·8	SW
21	30·529	30·509	30·452	30·422	42·8	36·8	SE	21	30·346	30·307	30·220	30·136	46·8	43·6	SSE
22	30·366	30·376	30·336	30·294	51·4	37·3	SSW	22	29·988	29·956	29·982	30·015	52·5	45·0	NNE
23	30·238	30·258	30·233	30·193	53·2	41·8	SW	23	30·070	30·162	30·128	30·035	47·1	38·9	SW
24	30·050	29·935	29·736	29·518	52·3	45·0	SSE	24	29·854	29·671	29·381	29·166	47·2	39·8	SSW
25	29·272	29·513	29·635	29·727	52·5	35·6	W	25	29·187	29·303	29·463	29·538	45·5	33·0	WNW
26	29·724	29·692	29·609	29·609	43·9	32·0	WSW	26	29·491	29·446	29·476	29·544	33·9	28·7	NNE
27	29·606	29·672	29·791	29·997	35·7	29·8	NW	27	29·689	29·846	30·016	30·155	36·0	28·7	NNW
28	30·077	30·167	30·185	30·240	37·0	29·4	NW	28	30·181	30·189	30·178	30·177	39·0	29·1	SW
29	30·221	30·216	30·122	30·085	39·9	29·4	W	29	30·110	30·064	29·986	29·962	42·4	36·4	SW
30	30·065	30·122	30·139	30·234	41·9	29·3	W	30	29·920	29·956	29·969	30·051	44·8	40·7	SE

DECEMBER, 1889.

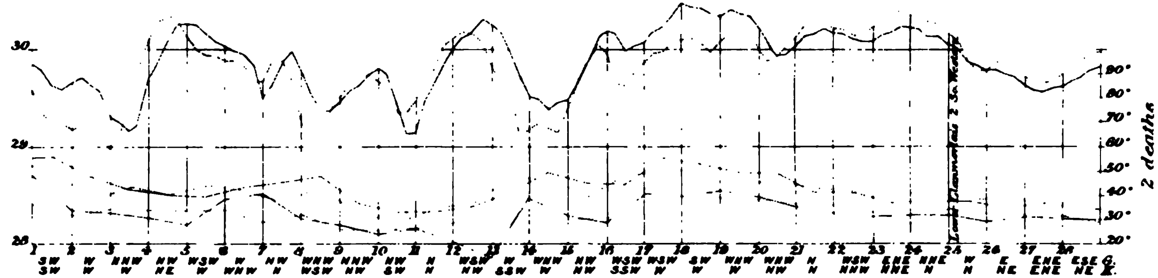
1	30·295	30·391	30·425	30·474	38·3	26·0	SE	1	30·091	30·179	30·206	30·239	44·7	41·6	S
2	30·454	30·493	30·446	30·466	36·6	25·8	SE	2	30·229	30·259	30·251	30·287	43·1	37·5	SE
3	30·447	30·456	30·430	30·434	32·6	25·9	E	3	30·307	30·305	30·361	30·405	39·7	31·8	ESE
4	30·428	30·468	30·456	30·490	35·2	24·6	E	4	30·434	30·485	30·479	30·525	38·8	30·7	ENE
5	30·526	30·569	30·594	30·621	37·1	32·2	NE	5	30·572	30·610	30·644	30·648	39·7	35·9	SW
6	30·571	30·574	30·473	30·379	37·5	33·9	NE	6	30·567	30·449	30·242	30·039	42·4	37·3	SW
7	30·214	30·085	30·056	30·163	35·1	32·2	SSW	7	30·005	30·116	30·134	30·134	43·6	35·3	W
8	30·227	30·296	30·237	30·172	37·4	31·9	NW	8	30·088	30·042	29·872	29·713	49·0	37·9	SSW
9	29·968	29·876	29·729	29·630	49·1	37·7	SW	9	29·578	29·471	29·347	29·278	50·9	40·7	W
10	29·520	29·415	29·267	29·278	48·3	34·1	SW	10	29·094	29·020	28·985	29·106	43·4	35·3	WSW
11	29·299	29·439	29·612	29·806	39·2	30·2	W	11	29·242	29·455	29·599	29·709	37·5	31·7	WNW
12	29·946	30·048	30·038	29·988	39·2	25·1	SW	12	29·768	29·793	29·663	29·441	41·4	30·3	NE
13	29·843	29·799	29·816	29·945	46·7	29·8	S	13	29·361	29·528	29·720	29·906	42·8	37·0	W
14	30·070	30·198	30·247	30·344	38·7	28·8	NNW	14	30·033	30·120	30·094	30·057	45·0	36·1	NE
15	30·385	30·428	30·437	30·436	41·1	33·0	SW	15	30·172	30·272	30·228	30·142	44·8	40·0	WSW
16	30·365	30·427	30·433	30·461	47·8	39·0	SW	16	30·045	30·186	30·229	30·189	47·7	41·4	W
17	30·438	30·449	30·411	30·402	52·0	47·6	SW	17	29·992	30·000	30·081	30·062	51·9	45·6	WSW
18	30·328	30·254	30·181	30·248	50·3	45·2	SSW	18	29·815	29·655	29·934	30·074	52·0	38·1	W
19	30·309	30·321	30·194	30·014	45·2	33·2	N	19	29·971	29·817	29·647	29·491	44·9	39·2	SW
20	29·810	29·656	29·735	29·802	46·1	36·3	SSW	20	29·464	29·462	29·371	29·370	41·3	34·0	SW
21	29·811	29·778	29·725	29·665	48·0	35·1	SW	21	29·385	29·448	29·502	29·488	41·0	34·1	WSW
22	29·538	29·544	29·540	29·623	51·9	46·0	WSW	22	29·358	29·327	29·378	29·524	38·1	34·0	NE
23	29·818	29·992	30·012	29·985	48·9	42·0	SW	23	29·684	29·761	29·724	29·582	46·7	36·8	SSW
24	29·813	29·668	29·911	30·169	51·8	39·1	W	24	29·387	29·403	29·716	29·983	48·0	36·0	WNW
25	30·344	30·477	30·494	30·527	44·9	30·0	W	25	30·183	30·243	30·213	30·234	46·6	35·8	SW
26	30·547	30·584	30·553	30·546	41·7	31·9	W	26	30·259	30·325	30·347	30·407	47·0	45·8	SW
27	30·512	30·496	30·380	30·305	41·1	33·1	ENE	27	30·399	30·415	30·395	30·369	46·0	37·2	S
28	30·228	30·251	30·250	30·274	34·4	26·3	ENE	28	30·292	30·249	30·145	30·106	36·9	28·8	SE
29	30·254	30·294	30·293	30·334	30·3	22·7	ENE	29	30·090	30·180	30·224	30·277	37·2	32·0	NW
30	30·334	30·391	30·382	30·392	34·0	29·9	ENE	30	30·256	30·246	30·138	30·045	44·5	36·6	SSW
31	30·355	30·339	30·281	30·305	33·4	25·5	ENE	31	29·946	29·890	29·815	29·986	47·1	38·4	SSW

1889

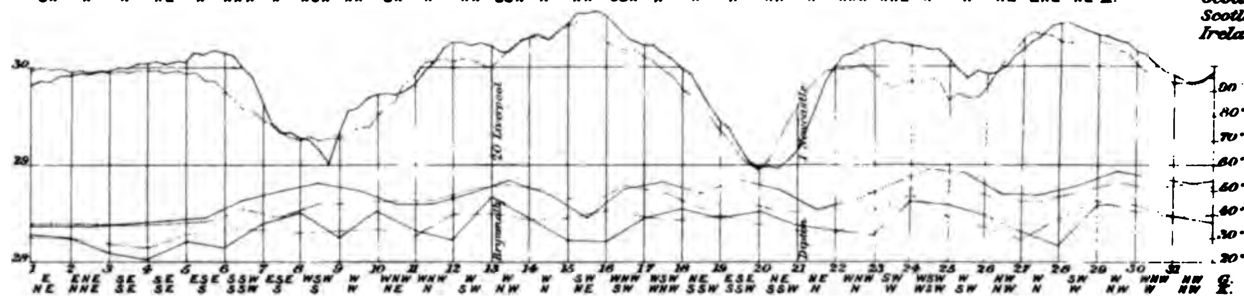
JANUARY



FEBRUARY



MARCH

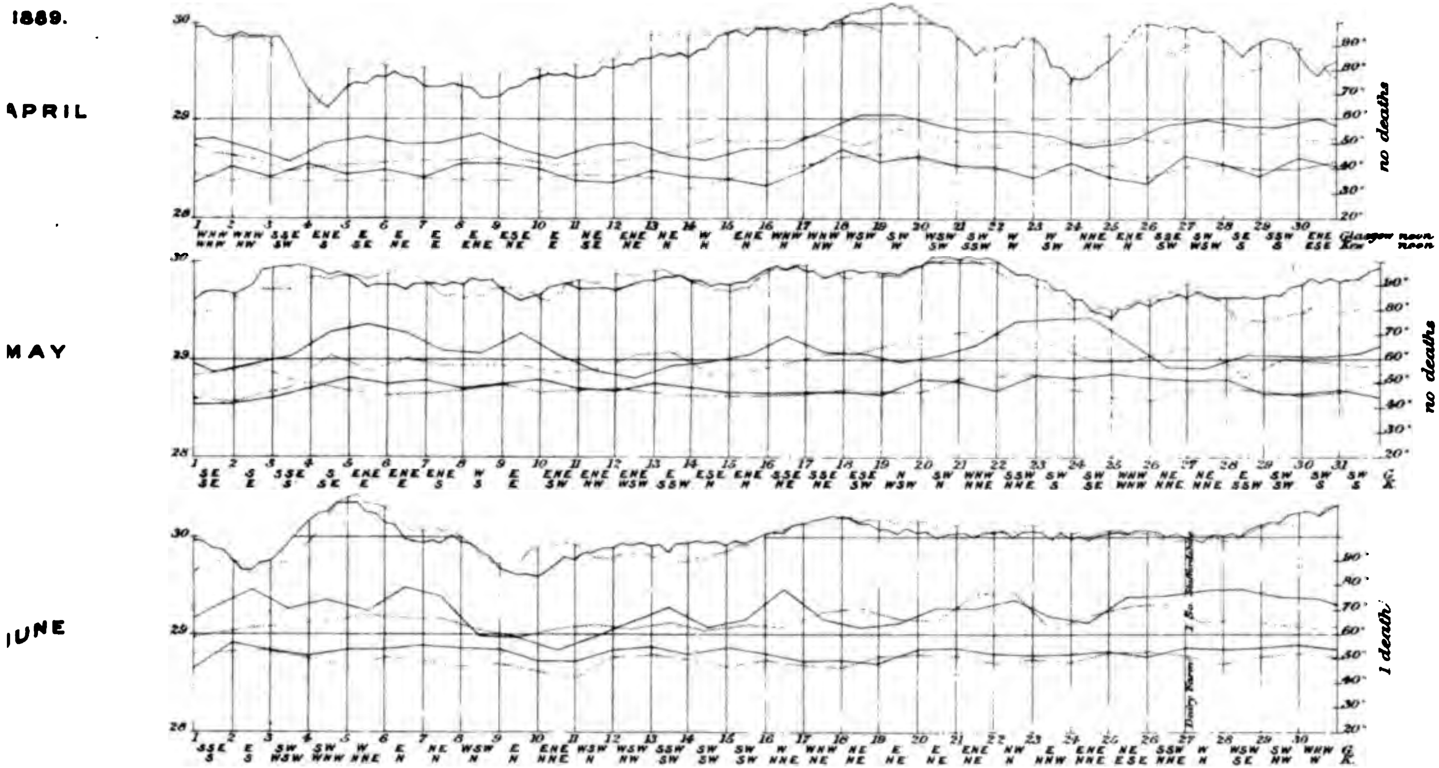


DEATHS FROM EXPLOSIONS OF FIRE DAMP DURING THE YEAR 1889 IN THE SEVERAL INSPECTION DISTRICT

Newcastle	7 Deaths
Durham	0
Manchester	0
Liverpool	20
Yorkshire	2
Midland	0
Staffords N.	90
Staffords S.	4
South Western	5
South Wales	2
Scotland East	1
Scotland West	5
Ireland	0
Total	136

The firm top line is the Barometer reading at Kew taken at 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm Glasgow lines are dotted.
The figures attached to the districts shew the Number of deaths caused by the explosions.

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



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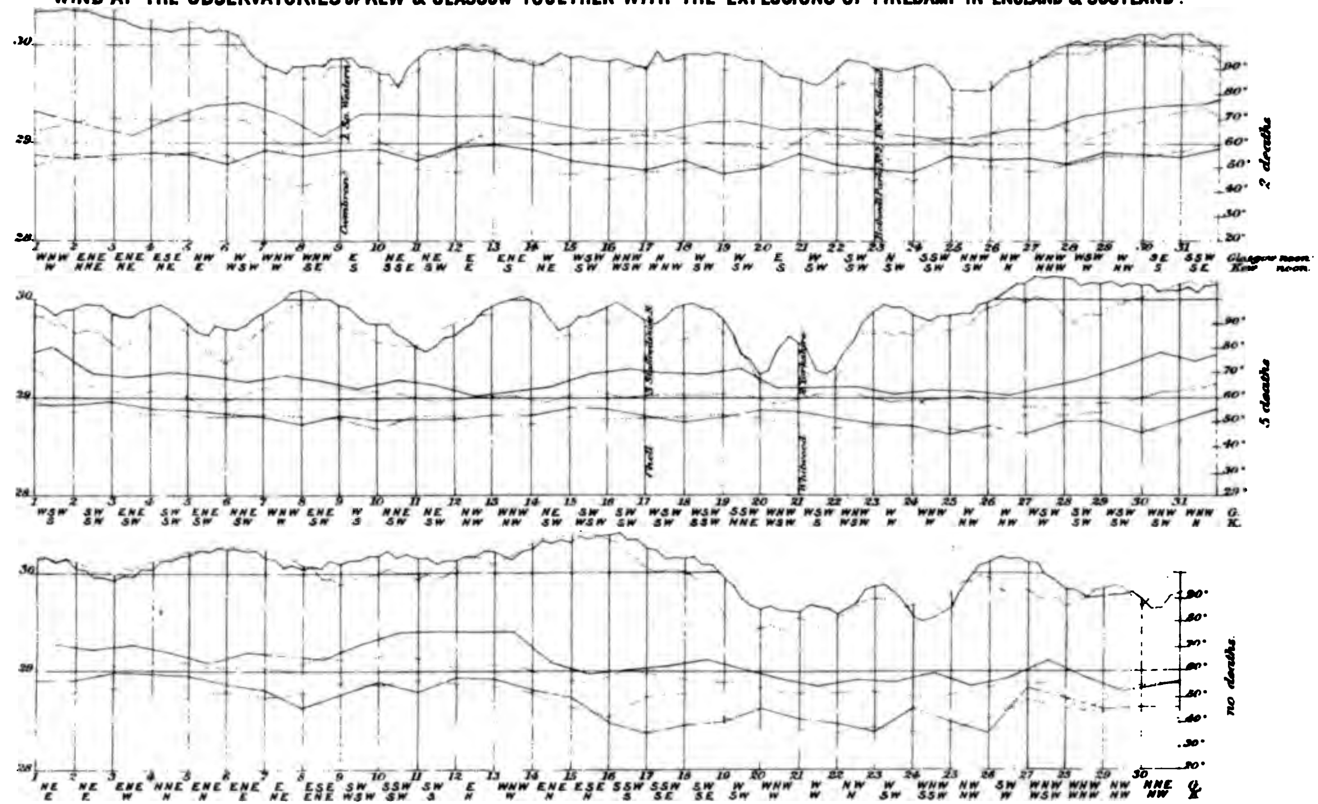

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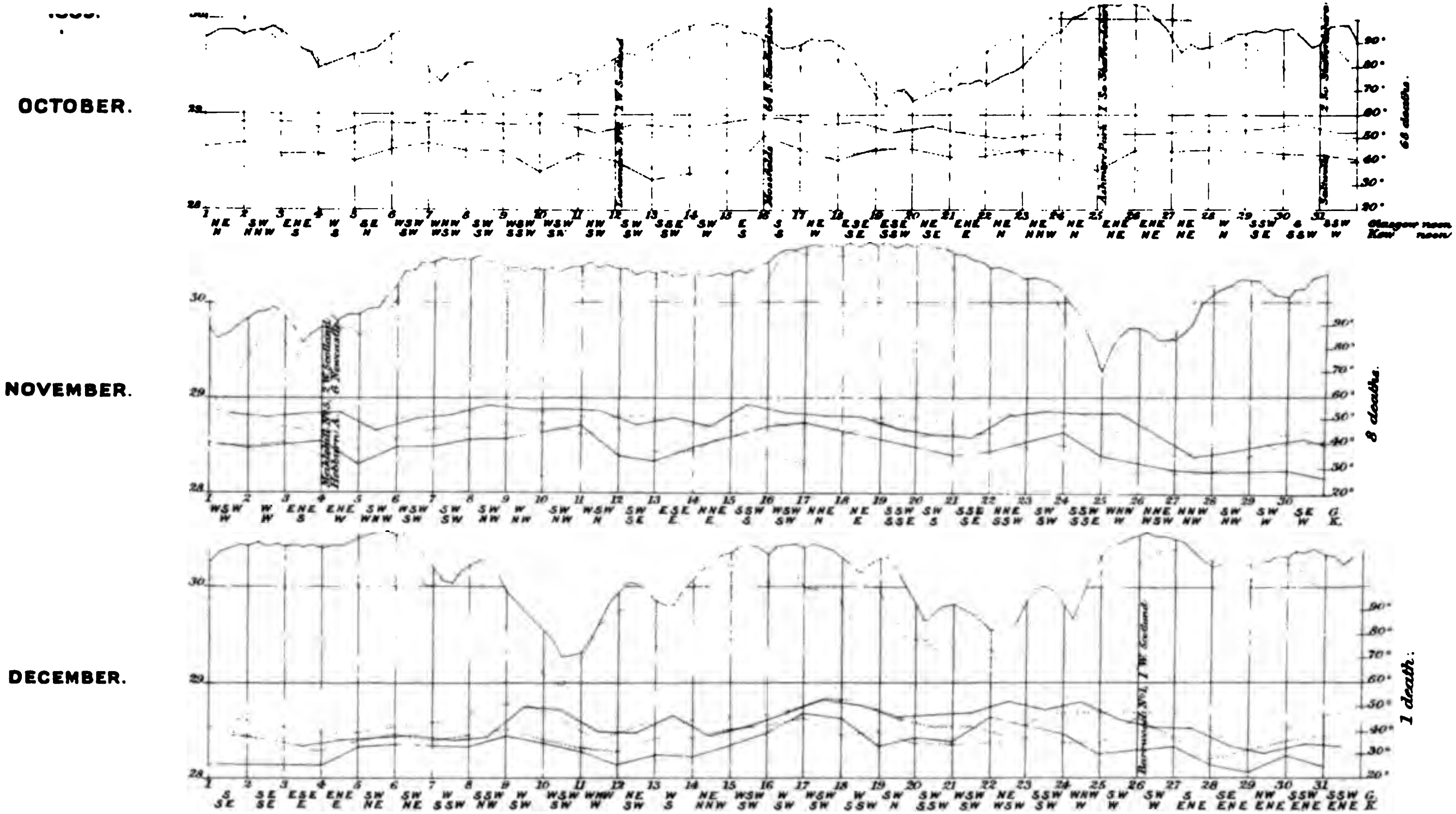
Proceedings N.E.I. of M. & M.E. 1889-90.



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Kew lines are firm Glasgow lines are dotted
The figures attached to the districts shew the Number of deaths caused by the explosions.

II.—REPORT OF THE CORRESPONDING SOCIETIES COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

The Corresponding Societies Committee of the British Association beg to report to the General Committee that the two meetings of the Conference of Delegates were held on Thursday, September 6, and Tuesday, September 11, 1888, at 3·30 p.m., in the Grammar School at Bath.

The following Delegates were nominated for the Bath Meeting:—

Rev. H. H. Winwood, M.A., F.G.S. ...	Bath Natural History and Antiquarian Field Club.
Mr. Wm. Gray, M.R.I.A.	Belfast Naturalists' Field Club.
Mr. John Brown...	Belfast Natural History and Philosophical Society.
Mr. Charles Pumphrey	Birmingham Natural History and Microscopical Society.
Mr. J. Kenward	Birmingham Philosophical Society.
Rev. T. Hincks, F.R.S.	Bristol Naturalists' Society.
Mr. H. T. Brown, F.G.S., F.C.S. ...	Burton-on-Trent Natural History and Archæological Society.
Mr. T. H. Thomas	Cardiff Naturalists' Society.
Rev. J. M. Mello, M.A., F.G.S. ...	Chesterfield and Midland Counties Institution of Engineers.
Mr. T. Cushing, F.R.A.S.	Croydon Microscopical and Natural History Club.
Mr. G. H. Bailey, D.Sc., Ph.D. ...	Cumberland and Westmoreland Association for the Advancement of Literature and Science.
Mr. J. C. Mansell-Pleydell, J.P. ...	Dorset Natural History and Antiquarian Field Club.
Mr. A. S. Reid, M.A., F.G.S.	East Kent Natural History Society.
Mr. Robert Brown, R.N.	East of Scotland Union of Naturalists' Societies.
Mr. Ralph Richardson, F.R.S.E. ...	Geological Society of Edinburgh.
Prof. R. Meldola, F.R.S., F.C.S. ...	Essex Field Club.
Mr. D. Corse Glen, F.G.S.	Geological Society of Glasgow.
Prof. F. O. Bower, M.A., D.Sc. ...	Natural History Society of Glasgow.
Dr. H. Muirhead...	Philosophical Society of Glasgow.
Mr. J. Hopkinson, F.L.S., F.G.S. ...	Hertfordshire Natural History Society and Field Club.
The Deemster Gill	Isle of Man Natural History and Antiquarian Society.
Mr. S. A. Adamson, F.G.S.	Leeds Geological Association.
Mr. G. F. Deacon, M. Inst. C.E. ...	Liverpool Engineering Society.
Mr. F. T. Mott, F.G.S.	Leicester Literary and Philosophical Society.
Mr. G. H. Morton, F.G.S.	Liverpool Geological Society.
Mr. Eli Sowerbutts, F.R.G.S.	Manchester Geographical Society.
Mr. Mark Stirrup, F.G.S.	Manchester Geological Society.

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Mr. R. G. Durrant	Marlborough College Natural History Society.
Mr. E. B. Poulton, M.A., F.L.S. ...	Midland Union of Natural History Societies.
Prof. G. A. Lebour, M.A., F.G.S. ...	North of England Institute of Mining and Mechanical Engineers.
Dr. J. T. Arlidge, M.A.	North Staffordshire Naturalists' Field Club.
Mr. C. A. Markham	Northamptonshire Natural History Society and Field Club.
Mr. Matthew Blair, F.G.S.	Paisley Philosophical Institution.
Mr. Robert Brown, R.N.	Perthshire Society of Natural Science.
Mr. H. R. Mill, D.Sc.	Royal Scottish Geographical Society.
Mr. W. Andrews	Warwickshire Naturalists' and Archæologists' Field Club.
Mr. J. W. Davis, F.G.S.	Yorkshire Geological and Polytechnic Society.
Rev. E. P. Knubley, M.A.	Yorkshire Naturalists' Union.

At the first Conference the chair was taken by Dr. John Evans, the Corresponding Societies Committee being represented by General Pitt-Rivers, Sir Douglas Galton, Professor Boyd Dawkins, Professor T. G. Bonney, Mr. W. Whitaker, Mr. G. J. Symons, Mr. W. Topley, Dr. Garson, Mr. J. Hopkinson, Mr. W. White, and Professor R. Meldola (Secretary).

The Ancient Monuments Act.

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Work of other Committees, and Suggestions.

Temperature Variation in Lakes, Rivers, and Estuaries.—

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Earth Tremor Committee.—Professor Lebour reported that the committee was about to apply for reappointment with the object of, in the first place, prosecuting enquiries as to the best form of instruments and the best conditions with respect to locality, foundation, etc., for fixing up such instruments. Several societies and individuals had expressed their willingness to co-operate as soon as these conditions had been determined, and the Birmingham Philosophical Society had made a grant towards the expenses of these preliminary trials.

Flameless Explosives.—Professor Lebour stated also that the North of England Institute of Mining and Mechanical Engineers had recently appointed a committee armed with a substantial grant to make a series of experiments on so-called "Flameless Explosives." This committee was now at work, and would gladly receive assistance in any way from kindred societies.

The same Institute had joined with the mining institutes of South Wales and Scotland in forming another committee to conduct a series of experiments on fan-ventilation. He thought that these were examples of the kind of co-operation which the Conference of Delegates of Corresponding Societies was likely to bring about.

At the second Conference the chair was first taken by the Secretary (Professor R. Meldola), and afterwards by the Vice-Chairman (Mr. W. Whitaker), the committee being further represented by Mr. J. Hopkinson and Mr. W. White, and towards the close of the meeting by Dr. Evans, who had been detained at the Committee of Recommendations.

SECTION A.

Temperature Variation in Lakes, Rivers, and Estuaries.—

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SECTION B.

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SECTION C.

Professor Lebour, who had been nominated as the representative of the Committee of this Section, said that the Committee on (1) Sea-Coast Erosion, (2) Underground Waters, (3) Erratic Blocks, and (4) Earth Tremors, the working of which had been explained to the Delegates on former occasions, had been recommended for reappointment.

Geological Photography.—Professor Lebour further informed the Delegates that in consequence of a paper read before Section C by Mr. O. W. Jeffs on local geological photographs, it was proposed by the Committee of the Section that a committee should be appointed to collect and register such photographs. The proposal at present was so indefinite that there was no chance of the Committee of Recommendations dealing with it that year, but they gave the suggestion their cordial sympathy, and it was formally passed on to the meeting of Delegates. It was hoped that Delegates of Corresponding Societies, by discussing the matter among themselves, would have it so organized and ready to place before the Committee of the Section next year, and ultimately before the Committee of Recommendations, in such a form that a Committee of the Association might be appointed, with a small grant, to work the scheme satisfactorily. It was thought by the Committee of the Section that too many restrictions as to the uniformity of the photographs should not be enforced in the early stages of the scheme. The simple collection and registration of photographs was all that was at present aimed at.

The following suggestions with reference to this subject were forwarded by the Committee of the Section to the Secretary of the Conference:—

"1. That a Committee be formed, having representatives for each county, charged with the arrangements of a local photographic survey for geological purposes in each district.

"2. The Committee will gather together—

(*a*) Names of societies and individuals who have already assisted in this object, or who are willing to do so;

(*b*) Copies of geological photographs already taken;

(*c*) List of localities, sections of rocks, boulders, and other features desirable to be photographed;

and will arrange with local societies for the work to be done as may be convenient or possible.

"3. Each photograph to be accompanied by the following particulars:—

(*a*) Name and position of locality or section;*

(*b*) Details of features shown (with illustrative diagram or sketch whenever necessary for such explanation);

(*c*) Scale of height and length, or figure introduced to indicate size in nature;

(*d*) Name of photographer and Society under whose direction the view is taken;

(*e*) Date when photographed.

"4. Size of photograph recommended: 12 in. × 10 in., but this is not compulsory.

"5. Original negative to be the property of the society or individual under whose direction it is taken, and who shall also fix a price at which copies may be sold.

"6. One copy of each photograph to be the property of the British Association, and one other copy to be given to the Geological Society of London.

"7. Each photograph officially received to be numbered and recorded in a reference-book, and a list published and circulated showing price at which members and others may purchase them.

"8. A circular to be issued to all geological societies inviting their co-operation."

Mr. Jeffs said that a large number of societies in different parts of the kingdom had taken from time to time photographs of various geological sections and features as they came under their notice, but there had been no systematic way adopted either of collecting the photographs or of recording them, so that geologists interested might really know what had been taken. He thought that if some arrangement could be made, a great deal of good might be done, not only for the benefit of geological science, but also for educational purposes. Regarding regulations, he was not desirous of laying down any strict rules, but he thought that if the scheme were to be carried out at all satisfactorily and at a minimum expenditure, some few regulations would be necessary.

Mr. Whitaker thought it a very fit subject for the Conference, and trusted that Delegates would get their societies to think it over. The object was to interest all the societies and to have an harmonious result.

Some further discussion took place with reference to the requirements of the proposed committee and the mode of procedure in the field, in the course of which it was pointed out that the chief object was to secure photographs of typical and especially of temporary sections. The details of manipulation, the size of the photographs, method of mounting, registration of scale, etc., could only be settled when the Corresponding Societies had taken action in the matter and the committee had been formally appointed.

International Geological Congress.—Mr. Hopkinson called the attention of the Delegates to this Congress, which met in London last year, and pointed out the conditions under which societies could get the volume of Proceedings. He suggested that every society which intended to publish geological maps should ascertain the rules as to nomenclature and colouring adopted by the Congress, so that some degree of uniformity might be arrived at.

SECTION D.

Life-histories of Native Plants.—

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Suggestions for those studying the Life-histories of British Flowering Plants:—

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Disappearances of Native Plants.—

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Societes not enrolled as Corresponding Societies.

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At the conclusion of the Conference votes of thanks were passed to the Chairman and Secretary.

The Corresponding Societies Committee have received applications for retention from all the societies on the list, and they recommend that the General Committee should sanction their retention. The Corresponding Societies Committee have also received and considered applications from six new societies, and they recommend that four of these, viz., the Hampshire Field Club, the Malton Field Naturalists' and Scientific Society, the Rochdale Literary and Scientific Society, and the Woolhope Naturalists' Field Club should be enrolled as Corresponding Societies of the British Association.

* Including compass direction.—*Sec. Corr. Soc. Comm.*

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1888–89.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Barnsley Naturalists' Society, 1867 ..	Barnsley Nat. Soc. ..	Public Hall, Barnsley. H. Wade, 10, Pitt Street	70	None	6s. and 10s. 6d.	Transactions, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. ..	Rev. H. H. Winwood, Royal Literary and Scientific Institution, Bath	87	5s.	10s.	Proceedings, annually.
Bedfordshire Archæological and Natural History Society, 1887	Beds. A. N. H. Soc. ..	F. A. Blaydes and F. B. W. Phillips, M.A., Harpur Place, Bedford	60	None	7s. 6d.	Transactions, occasionally.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square, R. M. Young, B.A.	Shrhldrs., 199 Members, 42 Hon. Assoc., 6	£7 per share None	Varies £1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1853..	Belfast Nat. F. C. ..	William Swanston, F.G.S., 50, King Street, Belfast	290	None	5s.	Report and Proceedings, annually.
Birmingham Natural History and Microscopical Society, 1864	Birm. N. H. M. Soc. ..	William P. Marshall, Mason College, Birmingham	201	None	£1 1s.	"Midland Naturalist," monthly.
Birmingham Philosophical Society ..	Birm. Phil. Soc.	B. C. A. Windle, Medical Institute, Birmingham	120	None	£1 1s.	Proceedings, annually.
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	University College, Bristol. Professor Adolph Leipner, 47, Hampton Park, Redland, Bristol	208	5s.	10s.	Proceedings, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc..	46, High Street. G. Harris Morris, Ph.D., F.I.C., Avondale, Alexandra Road, Burton-on-Trent	167	None	5s.	Annual Report. Transactions, occasionally.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	R. W. Atkinson, B.Sc., F.I.C., 44, Loudoun Square, Cardiff	416	None	10s.	Report and Transactions, half-yearly.
Chester Society of Natural Science, 1871	Chester Soc. Nat. Sci...	Grosvenor Museum, Chester. G. R. Griffith and W. H. Okell	625	None	5s.	Annual Report. Transactions, every three or four years.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. W. F. Howard, 13, Cavendish Street, Chesterfield	263	£1 1s.	Members, 31s. 6d.; Subscribers, 21s.; Associates and Students, 20s.	Transactions, quarterly.
Cornwall, Mining Association and Institute of, 1884	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Tuckingmill, Camborne	350	None	Minimum, 10s. 6d.	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. ..	G. B. Millett, Penzance..	100, and 16 Associates	None	£1 1s.	Report and Transactions, annually.
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C. ..	W. Low Sarjeant, 7, Belgrave Road, South Norwood, S.E.	294	None	10s.	Proceedings and Transactions, annually.
Cumberland and Westmorland Association for the Advancement of Literature and Science, 1876	Cumb. West. Assoc. ..	J. B. Bailey, 28, Eaglesfield Street, Maryport	910	None	5s.	Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C. ..	M. G. Stuart, New University Club, St. James' Street, London, S.W.	200	None	10s.	Proceedings, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1876	Dum. Gal. N. H. A. Soc.	Dumfries. E. J. Chinnock, The Academy, Dumfries	213	2s. 6d.	2s. 6d.	Transactions and Journal of Proceedings, occasionally.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1888-89.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
East Kent Natural History Society, 1858	E. Kent N. H. Soc.	Frank Baker, Canterbury	75	None	10s.	Transactions, occasionally.
East of Scotland Union of Naturalists' Societies, 1884	E. Scot. Union	William D. Sang, 12, Townsend Crescent, Kirkcaldy, N.B.	11 Societies 1,053 Membs.	None	Assessment of 4d. per member	Proceedings, annually.
Edinburgh Geological Society, 1834	Edinb. Geol. Soc.	H. M. Cadell, 5, St. Andrew Square, Edinburgh	234	10s. 6d.	12s. 6d.	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, 7, Knighton Villas, Buckhurst Hill, Essex	400	10s. 6d.	10s. 6d.	"Essex Naturalist," quarterly.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	J. B. Murdoch, Capelrig, Mearns, Glasgow	250	None	10s.	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc.	D. A. Boyd and J. Trotter, 207, Bath Street, Glasgow	377	7s. 6d.	7s. 6d.	Proceedings and Transactions, annually.
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc.	John Mayer, 207, Bath Street, Glasgow	642	£1 1s.	£1 1s.	Proceedings, annually.
Hampshire Field Club, 1885	Hants. F. C.	Hartley Institution, Southampton. T. W. Shore and W. Dale	200	None	5s.	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc.	Dr. J. Morrison, F.G.S., Victoria Street, St. Albans	252	10s.	10s.	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C.	A. J. Crosfield, Carr End, Reigate	78	10s.	10s.	Proceedings, usually every two years.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc.	Thomas Wallace, High School, Inverness	146	None	5s.	Transactions, occasionally.
Ireland, Royal Geographical Society of, 1831	R. Geol. Soc. Ireland	Prof. W. J. Sollas, F.R.S., Trinity College, Dublin	140	None	£1 1s.	Journal, generally annually.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland	Prof. C. F. Bastable, 35, Molesworth Street, Dublin	150	None	£1.	Journal, annually.
Leeds Geological Association, 1874	Leeds Geol. Assoc.	S. A. Adamson, F.G.S., 52, Well Close Terrace, Leeds	114	None	5s.	Transactions, annually.
Leicester Literary and Philosophical Society, 1837	Leicester Lit. Phil. Soc.	C. J. Billson, M.A., St. John's Lodge, Clarendon Park Road, Leicester	348	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875	Liv'pool E. Soc.	Royal Institution. J. H. T. Turner, 3, Cook Street, Liverpool	180	None	£1 1s.	Transactions, annually.
Liverpool Geological Society, 1858	Liv'pool Geol. Soc	Royal Institution. W. Hewitt, B.Sc.	58	None	£1 1s.	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit. Phil. Soc.	Royal Institution. John Rutherford, LL.B., Wason Chambers, 4, Harrington Street, Liverpool	271	10s. 6d.	£1 1s.	Proceedings, annually.
Liverpool Microscopical Society, 1868	Liv'pool Mic. Soc.	Royal Institution. T. W. Bruce, 27, Wapping, Liverpool	133	10s. 6d.	10s. 6d.	Report, annually; Transactions, occasionally.
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc.	Thomas J. Blanche, Malton, Yorkshire	95	None	2s. 6d. and 5s.	Report, every two years.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Seabridge Cottage, Ramsey, Isle of Man	120	2s. 6d.	Gentlemen, 6s.; Ladies, 3s.	Yn Lioar Manninagh, quarterly.
Manchester Geographical Society, 1885	Manch. Geog. Soc.	Eli Sowerbutts, F.R.G.S., 44, Brown Street, Manchester	700	None	Ordinary, £1 1s.; Associates, 10s. 6d.	Journal, quarterly.
Manchester Geological Society, 1838	Manch. Geol. Soc.	Mark Stirrup, F.G.S., 36, George Street, Manchester	214	None	£1.	Transactions, about nine parts per annum.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1888–89.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Manchester Statistical Society, 1833 ..	Manch. Stat. Soc. ..	Francis E. M. Beardsall, 25, Booth Street, Manchester	Ordinary, 184	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	160	1s. 6d.	3s.	Report, annually.
Midland Union of Natural History Societies, 1877	Mid. Union	Thomas H. Waller, 71, Gough Road, Birmingham	2,000	—	—	"Midland Naturalist," monthly.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	Prof. G. A. Lebour, Neville Hall, Newcastle-on-Tyne	730	None	21s., 42s., 63s.	Transactions, about every two months.
North Staffordshire Naturalists' Field Club and Archæological Society, 1865	N. Staff. N. F. C. A. Soc.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	401	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton N. H. Soc. ..	The Museum, Guildhall Road, Northampton. H. N. Dixon	200	None	10s.	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	W. Handley Kay, Gresham Chambers, Beastmarket Hill, Nottingham	Honorary, 8; Ordinary, 150; Corresponding, 10	None None None	None 5s. 2s. 6d.	Transactions and Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley	302	5s.	Members, 7s. 6d.	Report, annually.
Penzance Natural History and Antiquarian Society, 1839.	Penz. N. H. A. Soc. ..	G. F. Tregelles, Devon and Cornwall Bank, Penzance	93	None	10s. 6d.	Report and Transactions, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	309	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Union Street, Rochester	110	None	5s. or 10s.	"Rochester Naturalist," quarterly.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, 20, King Street South, Rochdale	221	None	5s.	Transactions, occasionally.
Royal Scottish Geographical Society, 1884	R. Scot. Geog. Soc. ..	80A, Princes Street, Edinburgh. A. Silva White	1,162	None	£1 1s.	"Scottish Geographical Magazine," monthly.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	David Gill, F.R.S., Royal Observatory, Cape Town	72	None	£2	Transactions, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	W. G. Fretton, F.S.A., 88, Little Park Street, Coventry	70	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	H. Cecil Moore, Hereford	About 200	10s.	10s.	Transactions, annually.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	James W. Davis, F.G.S., Chevinedge, Halifax	240	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, Sunny Bank, Leeds; and Rev. E. P. Knubley, Staveley Rectory, Leeds	375 and 2,109 Associates	None	10s. 6d.	Transactions, annually; "The Naturalist," monthly.

INDEX OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY THE ABOVE-NAMED SOCIETIES DURING THE YEAR ENDING JUNE 1, 1889.*

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Baker, J. G.	North Yorkshire: Studies of its Botany, Geology, Climate, and Physical Geography (second instalment). Second Edition	Yorks. Nat. Union	*Trans.*	3	49	1889
Lebour, Prof. G. A.	Barometer and Thermometer Readings for 1887 (with reference to Explosions in Mines)	N. Eng. Inst.	"	37	261	—
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Section B.—CHEMICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Bedson, Prof. P. P.	A Contribution to our Knowledge of Coal-dust	N. Eng. Inst.	*Trans.*	37	245	—
Brown, M. W., and Prof. Bedson	Explosion of an Air Receiver at Ryhope Colliery	" "	"	"	197	—
Foster, Dr. C. Le Neve	On Testing Impure Air	Cornw. Min. Assoc. Inst.	"	II.	—	—
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Section C.—GEOLOGY.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Adamson, S. A.	Reports of Field Excursions in 1888	Leeds Geol. Assoc.	*Trans.*	IV.	206	1889
" "	The Yorkshire Boulder Committee and its Second Year's Work	Yorks. Nat. Union	*The Naturalist*	For 1888	332	1888
" " and A. Harker	Geological Bibliography for North of England for 1886	" "	" "	"	178	"
Adamson, S. A., and A. Harker	Geological and Palæontological Bibliography for 1887	" "	" "	For 1889	61	1889
Aitken, Dr.	Formation of Granite	Inverness Sci. Soc.	*Trans.*	II.	1	—
Baker, J. G.	North Yorkshire: Studies of its Botany, Geology, Climate, and Physical Geography (second instalment). Second Edition	Yorks. Nat. Union	"	3	49	1889
Balderston, R. R.	Evidences of Glacial Action near Ingleton	" "	*The Naturalist*	For 1888	189	1888
" "	The Succession of the Silurian Rocks of Ingleton and the included Trap-dykes of most interest	" "	" "	For 1889	131	1889
Beasley, H. C.	Some irregularly striated joints in the Keuper Sandstone of Lingdale Quarry	Liverpool Geol. Soc.	*Proc.*	V.	386	1888

* The Titles of Papers on other than Mining and Mechanical Engineering, etc., have not been reprinted.

Section C.—GEOLOGY.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Bedford, J. E.	Notes on the Isle of Man	Leeds Geol. Assoc.	*Trans.*	IV.	177	1889
,, ,,	The Oil-fields of America and Russia	,, ,,	,,	,,	187	,,
Bell, W. H.	On Geognosy of the Cruachan District	Edinburgh Geol. Soc.	,,	V.	513	1888
Binnie, W. J. E.	The Mesozoic Rocks of the North-east Coast of Ireland	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	53	1889
Bird, C.	The Krakatoa Eruption	Rochester N. C.	*Roch. Naturalist*	1	397	,,
Bird, W. J.	The South Durham Salt Bed and associated Strata	Manch. Geol. Soc.	*Trans.*	XIX.	564	1888
,, ,,	Notes on Seaton Carew Boring	N. Eng. Inst.	,,	38	21	—
Blair, M.	The Surface Geology of Paisley	Paisley Phil. Inst.	*Proc.*	1	11	1889
Bolton, H.	On Fish Remains from the Lower Coal-measures of Lancashire	Manch. Geol. Soc.	*Trans.*	XX.	215	,,
Bramwell, H.	Notes on the Horizon of the Low Main Seam in a portion of the Durham Coal-field	N. Eng. Inst.	,,	37	151	—
Brown, H. T.	Notes on the Geology of the Hartshorne, Ticknall, and Melbourne District	Burt. N. H. Arch. Soc.	*Report*	Twelfth	21	1888
,, ,,	Notes on the Geology of the Milton, Ingleby, and Knowle Hills District	,, ,, ,,	,,	,,	23	,,
,, ,,	The Rhætic Beds	,, ,, ,,	*Trans.*	I.	1	1889
,, ,,	A Chapter in the Physical Geography of the Past	,, ,, ,,	,,	,,	37	,,
Cheetham, W.	From the Millstone Grits to the Silurians	Leeds Geol. Assoc.	,,	IV.	194	,,
Christy, M., and W. H. Dalton	Notes on an Alluvial Deposit in the Cann Valley, with a List of the Mollusca occurring therein	Essex F. C.	*Essex Naturalist*	III.	1	,,
Claypole, Prof. E. W.	The Eccentricity Theory of Glacial Cold *versus* the Facts	Edinb. Geol. Soc.	*Trans.*	V.	534	1888
Craig, G.	The Culbin Sandhills	,, ,,	,,	,,	524	,,
Crosskey, Dr. H. W.	Notes on the Glacial Geology of the Midlands	Birm. Phil. Soc.	*Proc.*	VI.	169	—
Davis, J. W.	Summary of Geological Literature relating to Yorkshire published during 1888	Yorks. Geol. Poly. Soc.	,,	XI.	128	1889
Dawkins, Prof. W. Boyd	On the Conglomerates of the South of the Island	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	16*a*	,,
,, ,, ,,	On the Clay Slates and Phyllites of the South of the Isle of Man, and a Section of the Foxdale Mine, Isle of Man	Manch. Geol. Soc.	*Trans.*	XX.	53	1888
De Rance, C. E.	Notes on the Vale of Clwyd Caves	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	1	1889
Dickson, E.	Geological Notes on the Preston Dock Works and Ribble Development Scheme	Liverpool Geol. Soc.	,,	V.	369	1888
Editor	Excursion of Edinburgh and Glasgow Geological Societies to Mid-Calder, June 30, 1888	Edinb. Geol. Soc.	*Trans.*	,,	549	,,
Elwes, J. W.	Sections on the Railway from Foreham to Netley	Hants. F. C.	*Proc.*	2	31	—
Firth, W. A.	The Diatomaceous Deposits at Lough Mourne	Belfast Nat. F. C.	*Report and Proc.*	III.	62	—
Fordham, H. G.	A Record of Water-level in a deep Chalk Well at Barley, Herts.	Herts. N. H. Soc.	*Trans.*	V.	20	1888
Forrester, J.	Hæmatite Iron Ore found in the neighbourhood of Kirkcaldy	E. Scot. Union	*Proc.*	For 1888	10	1889
Forster, T. E.	Coal Nodules from the Borehole Seam at Newcastle, New South Wales	N. Eng. Inst.	*Trans.*	37	145	—
Fraser, J.	Clay Shell Bed at Clava	Inverness Sci. Soc.	,,	II.	169	—
Gardner, J. S.	The Trap Formation of Ulster	Belfast Nat. F. C.	*Report and Proc.*	I.	49	—
Goodchild, J. G.	The Physical History of Greystoke Park and the Valley of the Petteril	Cumb. West. Assoc.	*Trans.*	XIII.	89	1888
,, ,,	The Old Lakes of Edenside	,, ,,	,,	,,	105	,,
Green, Prof. A. H.	Glassy Lavas and Devitrification	Leeds Geol. Assoc.	,,	IV.	186	1889
Harker, A.	The Igneous Dykes of the North of England	Yorks. Nat. Union	*The Naturalist*	For 1888	349	1888
Harman, F. E.	The Cerros of Famatina	Cornwall R. Geol. Soc.	*Report and Trans.*	XI.	162	1889
Hewitt, W.	Notes on Glacial Deposits and Markings in the South of the Isle of Man	Liv'pool Geol. Soc.	*Proc.*	V.	352	1888
Holgate, B.	The Magnesian Limestones of Yorkshire	Leeds Geol. Assoc.	*Trans.*	IV.	182	1889

Section C.—GEOLOGY.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Holgate, B.	Notes on the Lake District	Leeds Geol. Assoc.	*Trans.*	IV.	204	1889
Holland, P., and E. Dickson	Examination of Quartzite from Nills Hill, Pontesbury	Liv'pool Geol. Soc.	*Proc.*	V.	380	1888
Holmes, T. V.	The Subterranean Geology of South-eastern England	Essex F. C.	*Essex Naturalist*	II.	138	,,
Horne, J.	Andalusite Schists in Banffshire and Aberdeenshire	Inverness Sci. Soc.	*Trans.*		224	—
Johnstone, A.	The Microscopic Determination of Igneous Rocks	Edinb. Geol. Soc.	,,	V.	488	1888
Jolly, W.	Succession of Rocks in the North-west of Sunderland	Inverness Sci. Soc.	,,	II.	199	—
Kendall, P. F.	The Volcanic Phenomena of Mull	Manch. Geol. Soc.	,,	XX.	114	1889
,, ,,	On a large Boulder found in Oxford Street, Manchester	,, ,,	,,	,,	140	,,
Kidson, E.	Evidences of Glacial Action in Snowdonia	Nott. Nat. Soc.	,,	For 1888	14	,,
Lamplugh, G. W.	The Yellowstone Geysers	Leeds Geol. Assoc.	,,	IV.	179	,,
Law, R.	On Bones of Pleistocene Animals found in a broken-up Cave in a Quarry near Matlock, Derbyshire	Rochdale Lit. Sci. Soc.	,,	I.	15	1888
Lean, J.	Dolomitic Conglomerate of Bristol	Bristol Nat. Soc.	*Proc.*	V.	207	,,
McDonald, K.	Glacial Drift in Craggy Burn	Inverness Sci. Soc.	*Trans.*	II.	47	—
McNair, P.	The Geology of the Breadalbane District of Perthshire	Perth Soc. N. Sci.	*Trans. and Proc.*	I.	52	1888
Mansell-Pleydell, J. C.	Fossil Reptiles of Dorset	Dorset N. H. A. F. C.	*Proc.*	IX.		—
Martin, F. W.	First Report upon the Distribution of Boulders in South Shropshire and South Staffordshire	Birm. Phil. Soc.	,,	VI.	93	—
Melvin, J.	Inaugural Address	Edinb. Geol. Soc.	*Trans.*	V.	485	1888
,, ,,	The Parallel Roads or "Seter" of Norway	,, ,,	,,	,,	516	,,
Morgan, Prof. C. Lloyd	The Mendips: A Geological Reverie	Bristol Nat. Soc.	*Proc.*	,,	236	,,
,, ,,	The Stones of Stanton Drew: Their Source and Origin	,, ,,	,,	,,	261	,,
Morison, W.	A New Mineral Tar in Old Red Sandstone, Ross-shire	Edinb. Geol. Soc.	*Trans*	,,	500	,,
Morton, G. H.	Local, Historical, Post-Glacial, and Pre-Glacial Geology	Liv'pool Geol. Soc.	*Proc.*	,,	303	,,
,, ,,	Stanlow, Ince, and Frodsham Marshes	,, ,,	,,		349	,,
Oldham, T.	On the Cause of Earthquakes, of the Dislocation and Overlapping of Strata, and of Similar Phenomena	Manch. Geol. Soc.	*Trans.*	XX.	128	1889
Quilter, H. C.	The Rhætics of Leicestershire	Leicester Lit. Phil. Soc.	,,	XI.	14	,,
Reade, T. M.	Notes on the Geology of St. David's, Pembrokeshire	Liv'pool Geog. Soc.	*Proc.*	V.	358	1888
,, ,,	Notes on a large Boulder found in driving a Sewer Heading in Oxford Road, Manchester	,, ,,	,,	,,	377	,,
,, ,,	The New Red Sandstone and the Physiography of the Triassic Period	Yorks. Nat. Union	*The Naturalist*	For 1889	108	1889
Richardson, R.	Obituary Notice of Mr. Henry Cadell, of Grange	Edinb. Geol. Soc.	*Trans.*	V.	502	1888
,, ,,	Obituary Notice of Dr. Hayden	,, ,,	,,	,,	532	,,
,, ,,	On the Earthquake Shocks experienced in the Edinburgh District on Friday, January 18, 1889	R. Scot. Geog. Soc.	*Magazine*	,,	136	1889
Robson, Rev. G.	Past and Present Glaciers in Norway	Inverness Sci. Soc.	*Trans.*	II.	179	—
Rolder, C.	Some further Remarks on the Oxford Street Section	Manch. Geol. Soc.	,,	XX.	163	1889
Sington, T.	On the recently-disclosed Sections of the Superficial Strata along Oxford Street, Manchester	,, ,,	,,	XIX.	603	1888
Spencer, J.	On the Occurrence of a Boulder of Granitoid Gneiss, or Gneissoid Granite, in the Halifax Hard Bed Coal	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	96	1889
Symons, B.	The Gold-fields of Nova Scotia	Cornw. Min. Assoc. Inst.	*Trans.*	II.	—	—
Tate, A. N.	On the Colouring Matter of the Mineral "Blue John"	Liv'pool Geol. Soc.	*Proc.*	V.	384	1888

Section C.—GEOLOGY.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Thompson, B.	The Upper Lias of Northamptonshire	N'ton N. H. Soc.	*Journal*	5	54	1888
Topley, W.	Recent Earthquakes	Croydon M. N. H. C.	*Proc. and Trans.*	3	lxx.	1889
Turner, W.	The Porcelain Works at Nanthgarw	Cardiff Nat. Soc.	*Report and Trans.*	XX.	1	1888
Vine, G. R.	Notes on the Polyzoa of Caen and Ranville now preserved in the Northampton Museum	N'ton N. H. Soc.	*Journal*	5	1	,,
,, ,,	Notes on the Classification of the Palæozoic Polyzoa	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	20	1889
	A Monograph of Yorkshire Carboniferous and Permian Polyzoa. Part I.	,, ,,	,,	,,	68	,,
Wallace, T.	Shell Bed at Adersier	Inverness Sci. Soc.	*Trans.*	II.	176	—
,, ,,	Recent Geological Changes in the Moray Frith	,, ,,	,,	,,	380	—
Waller, T. H.	The Separation of Rock Constituents by means of Heavy Solutions	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	91	1889
Watts, W.	Distribution of Erratics and Boulder Clay on the lower portions of the Drainage Area of the Oldham Corporation Waterworks	Manch. Geol. Soc.	*Trans.*	XIX.	584	1888
,, ,,	On the Use of Roburite and other Explosives in Mines	,, ,,	,,	XX.	211	1889
White, J. W.	Flora of the Bristol Coal-field	Bristol Nat. Soc.	*Proc.*	V.	22[illegible]	1888
Worth, R. N.	Some Detrital Deposits associated with the Plymouth Limestone	Cornw. R. Geol. Soc.	*Report. and Trans.*	XI.	151	1889

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Section D.—BIOLOGY.

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Section E.—GEOGRAPHY.

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Section F.—ECONOMIC SCIENCE AND STATISTICS.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Darbishire, C. H.	Piece Work in the Manufacture of Plant and Machinery, and in the Construction of Ordinary Works	Liv'pool E. Soc	*Trans.*	VIII.	113	1888
Knowles, J.	On the Coal Trade	Manch. Geog. Soc.	,,	XX.	42	,,
O'Brien, M.	Sliding Scales for Rent Value and Fair Rents—Annual and Capital Value	Stat. Soc. Ireland	*Journal*	IX.	278	1889

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Section G.—MECHANICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Anderson, T. S.	The Telephone: Its Application and Developments	Cornw. Min. Assoc. Inst.	*Trans.*	II.	—	1889
Bennett, E. J.	Modern Crushing and Concentrating Machinery	,, ,,	,,		--	,,
Boche, H.	Experimental Determination of the Results of the Working of a new Fan (Capell), and the consequences deduced from these results	Chesterf. Mid. Count. Inst.	,,	XVII.	190	,,
Bramall, H.	On the effects of Roburite Fumes	Manch. Geol. Soc.	,,	XX.	158	,,
Brightmore, A. W.	The Flow of Water	Liv'pool E. Soc.	,,	VIII.	1	1888
Burrows, J. S.	Notes on working with the Edison-Swan Lamp	Manch. Geol. Soc.	,,	XX.	71	1889
Campbell, J. J.	Compound Engines for Atlantic Steam Navigation	Liv'pool E. Soc.	,,	VIII.	56	1888
Capell, Rev. G. M.	Mechanical Ventilation of Collieries, with a description of a new form of enclosed Mine Ventilator	Chesterf. Mid. Count. Inst.	,,	XVII.	174	1889

Section G.—MECHANICAL SCIENCE.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Committee	Federation of Mining Institutes	N. Eng. Inst.	*Trans.*	37	155	—
"	Mechanical Ventilators	" "	"	"	181	—
Cox, L. C.	A Double-acting Wedge for Getting Coal (Cox's patent)	Chesterf. Mid. Count. Inst.	"	XVII.	108	1888
Darbishire, C. H. ..	Sewer Ventilation	Liv'pool E. Soc.	"	VIII.	13	"
Fletcher, H.	On the Effects of Goaf Stowing on Sudden Issues of Gas and on Ventilation	Manch. Geol. Soc. ..	"	XX.	173	1889
Grundy, J.	On the Premature Explosions of Gunpowder	" "	"	"	84	"
Henderson, J	Telpherage	Cornw. Min. Assoc. Inst.	"	II.	—	"
Hilton, J.	On the Use of Roburite in Coal Mines	Manch. Geol. Soc. ..	"	XX.	92	"
Hollingworth, G. H. ..	The Phœnix Safety-lamp	" "	"	"	198	"
Hudleston F.	The Coal Shipping Appliances of the Port of Liverpool	Liv'pool E. Soc.	"	VIII.	75	"
Hunter, J.	Charles Pit, Flaggy Creek, Pit Heading: Description of Survey	N. Eng. Inst.	"	38	13	—
Lean, J.	Tunnelling through various Strata	Bristol Nat. Soc. ..	*Proc.*	V	147	—
Marley, J.	Presidential Address	N. Eng. Inst.	*Trans.*	38	29	—
Marshall, W. P.	On the successful Use of Oil to calm Rough Seas	Birm. N. H. M. Soc. ..	*Mid. Naturalist* ..	11	171	1888
Metcalfe, A. W.	Continuous Railway Brakes	Bristol Nat. Soc. ..	*Proc.*	V.	168	—
Meyer, G., and W. J. Bird	The use of Iron Supports in the Main Roads of Mines instead of Masonry or Timbering	N. Eng. Inst.	*Trans.*	37	135	—
Morison, J.	The Danger attending the use of light Mineral Oils for lubricating Air-compressing Machinery	" "	"	38	3	--
Platt, S. S.	Sewers and Drains (Ancient and Modern)	Rochdale Lit. Sci. Soc.	"	I.	28	1888
Pooley, H., Jun.	Automatic Weighing Machines	Liv'pool E. Soc.	"	VIII.	96	"
Richardson, C.	The Arch	Bristol Nat. Soc. ..	*Proc.*	V.	95	—
Sherratt, W.	Water Supply to large Towns	Manch. Geol. Soc. ..	*Journal*	4	58	1889
Simpson, H. H.	Future Engineering	Bristol Nat. Soc. ..	*Proc.*	V.	199	—
Spencer, C. J.	On the Setting of Steam Boilers	" "	"	"	133	
Steavenson, A. L. ..	On the Introduction of Steel Supports for the Maintenance of Main Roads in the Mines of Cleveland	N. Eng. Inst.	*Trans.*	37	221	—
Sturgeon, J.	The Birmingham Compressed Air Power Scheme	Liv'pool E. Soc.	"	VIII.	28	1888
Shaw, Prof. H. S. H. ..	Testing of Steam Engines	" "	"	"	42	"
Swete, O. R.	A new Miner's Electric Safety-lamp	Manch. Geol. Soc. ..	"	XX.	60	1889
Swiney, J. H. H.	Mechanical Removal of Deposit from Water Mains, as carried out at Omagh in 1887	Belfast N. H. Phil. Soc.	*Report and Proc.* ..	For 1888	61	1888
Thomson, J. H.	The Blackwall Artesian Well, Queensland	Manch. Geog. Soc. ..	*Journal*	4	168	1889
Townsend, C. H.	Art and Architecture: Their relation and subordination in Engineering Works	Liv'pool E. Soc.	*Trans.*	VIII.	85	1888
Vaudrey, J. C.	Notes on Practical Electricity, especially regarding its use as an Illuminant	" "	"	"	43	"
Webster, J. J.	Retiring Presidential Address	" "	"	"	118	"
Williams, R. H.	Proper and Improper Treatment of Steam Boilers	Cornw. Min. Assoc. Inst.	"	II.	—	1889
Winstanley-Wallis, T. M.	Electric Lighting and Transmission of Power in Mining	Chesterf. Mid. Count. Inst.	"	XVIII.	242	"

Section H.—ANTHROPOLOGY.

III.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF FOREIGN SOCIETIES AND FOREIGN PUBLICATIONS.

A HAND DIAMOND ROCK-BORING MACHINE.

Schwedische Diamantbohrmaschine für Handbetrieb des "Svenska Diamantberg-borrnings-Aktiebolag" in Stockholm. By E. GAD. *Berg- und Huettenmænnische Zeitung, Vol. xlviii., pp.* 451–454. *One figure.*

Mr. A. Craelius has recently invented a hand boring machine formed on the model of the American power drills, except as regards the advance motion, and its weight reduced to about 14 cwt., including 164 feet of bore-rods, force-pump and accessories. The boring crown is 1·38 inches outside and ·94 inch inside diameter, giving a core of from ·865 to ·905 inch. Eight diamonds of ·75 to ·8 carats are fitted into it in the usual manner. The core-tube, screwed on to the diamond crown, is 3 feet 3 inches long. The bore-rods are made of 4 feet 11 inches lengths of iron pipes of 1·30 inches outer and ·98 inch inner diameter. A force-pump supplies water to the boring crown through an india-rubber tube at the rate of 1·10 gallons per minute. The boring spindle, into which the bore-rod fitted, is rotated with wheel gearing by handles, the iron stand resembling that of a hand-winch in size and appearance. By hand the new machine can be driven at about 60 or 70 revolutions per minute against the 200 to 400 obtainable by power. The advance motion is obtained by a weighted lever, and the power is doubled by a pulley, a rope being led from the end of the lever over a pulley on the bore-rod to an eye on the iron frame. For shallow depths three workmen are required, and for deeper holes five workmen, in addition to a skilled foreman. The greatest speed attained with the new machine is 34 feet in 24 hours. The work becomes difficult and costly as the depth increases. With workmen's wages at 1s. 6d. per shift, the cost varies from 40s. to 50s. per fathom. The system is considered suitable for borings up to about 38 fathoms in any desired direction either in the mine or from the surface. A. R. L.

THE CONDITIONS OF FORMATION OF LIGNITE.

Alte Funde auf der Saalburg und die Lignitbildung. Von F. SEELAND. *Oesterr. Zeitschr. f. Berg- u. Hüttenwesen,* 1891, *Vol. xxxix., p.* 247.

The author has examined oak timber found in the remains of the Roman *castellum* of Saalburg, built on the Eastern Taunus in 17 B.C., destroyed in 282 A.D. This timber was used as lining for wells or cisterns (? for the baths) which were sunk about 30 feet below ground, and was thus long subjected to moderate pressure at the ordinary earth temperature. It is now mostly converted into a sort of lignite comparable with that of Köflach. O. S. E.

THE ORIGIN OF COAL.

Des diverses théories émises sur le mode de formation de la houille et d'une conclusion que l'on peut en tirer. By A. COCHETEUX. *Annales de la Soc. Géol. de Belgique,* 1885–86, *Vol. xiii., Bulletin, pp. clxix–clxxiii.*

After a brief recapitulation of the various theories extant on the formation of coal, the author enumerates his own conclusions with regard to the Belgian coal-field, as follows :—

1.—The Carboniferous Limestone is a deep sea formation.

2.—The soil of Belgium was slowly rising during the deposition of the Lower Coal-measures, and of equivalent strata without coal.

3.—During the deposition of the Belgian coal-seams, the land slowly subsided again. The dunes heaped up by the wind had formed a salt-lake, in which the sediment, brought down by the streams from the Ardenne and Brabant hills was deposited; the continual flow of fresh water sweetened the lake, and made the growth of vegetation possible; then the sea broke in again, and the preceding series of events was repeated many times over.

4.—A second time the land rose during the Upper Coal-measure and Permian age.

The author maintains that the above statements have been confirmed by his own observations in the collieries; and he intends to embody his theory in a more detailed work. O. S. E.

THE COAL DEPOSITS IN THE INDWE BASIN AND STORMBERG RANGE OF MOUNTAINS [CAPE OF GOOD HOPE].

Report by W. GALLOWAY, *and presented to the Legislature of the Colony.* 52 *pages and* 5 *Plates.*

This report on the Indwe coal-mines gives details as to the area of the deposit, quality of the coal, best means of working, and estimated value to the colony.

M. W. B.

THE ADAMS BEE-HIVE OVEN.

Coke-burning Simplified. By FRANK M. MCKELVEY *The Colliery Engineer, (Scranton, U.S.A.),* 1890, *Vol. x., p.* 130-131, *and three figures.*

The ordinary bee-hive oven is fitted with a portable oven bottom, worked by an hydraulic ram, and removable with its contents from the oven upon a four-wheeled carriage.

The movable bottom of the oven is built up of wrought-iron, of circular shape. The oven is built of the same diameter as an ordinary oven, but of greater height, to the extent of 3 feet, and is fitted with a door whose width is equal to the diameter of the oven.

The hydraulic ram is placed in the centre of the oven, and has a stroke of 3 feet.

The oven bottom is placed upon a small carriage, and pushed along a track until it is in the oven and directly over the hydraulic ram. The ram is then raised until the oven bottom presses against a shoulder built around the oven. When the bottom is in position, supports are dropped to keep it secure. The ram is withdrawn, the carriage removed from the oven, and the doors closed.

The oven is then charged and burnt off in the ordinary way.

In withdrawing the coke, the doors are opened, the carriage run under the oven bottom, the ram raised until the supports are withdrawn, and the oven bottom and coke is then lowered on to the carriage, which is run out of the oven. The coke is watered, and a chain placed round in it, and the mass dragged off the oven bottom.

M. W. B.

THE ADAMS IMPROVED BEE-HIVE COKE-OVEN.

By JOHN FULTON. *The Colliery Engineer,* 1890, *Vol. xi., pp.* 8 *and* 9, *and three figures.*

An Adams oven has been erected by the Cambria Iron Company, near Dunbar, and its produce is of good quality. A charge of $6\frac{1}{4}$ tons of coal produced 4 tons of coke, and the Adams oven was drawn $3\frac{1}{2}$ times per week; it was drawn easily in ·15 hour at a net cost of 3·12d. per ton; while the ordinary oven, with the same load of coal and produce of coke is drawn 3 times per week, was drawn in 3 hours at a cost of 10·44d. per ton.

The cost of a battery of 100 ovens of the ordinary bee-hive oven, producing 60,000 tons of coke per annum, may be calculated as under:—

100 ovens .... each £50 ...	£5,000			
Annual charges—				
Interest at 10 per cent.	£500	=	2·00d. per ton.	
Repairs and renewals, each £2 ...	200	=	·80d.	„
Loading ovens	240	=	·96d.	„
Levelling	480	=	1·92d.	„
Drawing, 60,000 tons...	2,610	=	10·44d.	„
Total	£4,030	=	16·12d.	„

The same quantity of coke would be produced by 85 Adams ovens, the cost of wnich would be:—

85 ovens ... ... each £100 ...	£8,500			
Annual charges—				
Interest at 10 per cent.	£850	=	3·40d. per ton.	
Repairs and renewals, each £3 ...	255	=	1·02d.	„
Loading ovens	255	=	1·02d.	„
Levelling	510	=	2·04d.	„
Drawing, 60,000 tons	780	=	3·12d.	„
Total	£2,650	=	10·60d.	„

M. W. B.

COPPER MINING IN SPAIN (HUELVA).

L'Industrie du Cuivre dans la Région d'Huelva (Rio-Tinto, San Domingos, etc.). By L. DE LAUNAY. *Annales des Mines*, 1889, *Sér.* 8, *Vol. xvi., pp.* 427–516, *and Plates X., XI., XII.*

The copper industry has existed many years at Huelva, on the south frontiers of Spain and Portugal, and the names of Rio-Tinto, Tharsis, etc., are become world-renowned. These mines are very interesting owing to their antiquity, the nature of their outcrops, the mode of working by quarry systems, the ingenious methods employed in the economical extraction of the copper from so poor a mineral, etc. and these details are all exhaustively described in this memoir. M. W. B.

A CYLINDRICAL DAM.

Note sur la Plate-cuve du Puits No. 1 *des Mines de Sel et Salines de Saint-Nicholas-Varangeville. Bulletin de la Société de l'Industrie Minérale, Third Series, Vol. i.*, 1887, *pp.* 1268–70. *Plate* 27, *Figs.* 4–9.

Owing to subsidences of the old workings in the vicinity of the No. 1 pit, in the eleventh bed of rock salt, at a depth of 525 feet, an influx of brine was found in the roof of the old workings at a depth of 275 feet in the fourth bed.

These feeders, small at first, quickly increased and threatened to flood not only the old workings but also the new workings, recently commenced around No. 2 pit, sunk about 1,050 feet to the east of No. 1 pit, the two pits being connected by a level in the eleventh bed.

The company therefore decided to fix in the No. 1 pit, between the level of the workings of the eleventh bed and that of the workings in the fourth bed, a dam to keep back the water of the old pits, as well as the feeders leaking from the tubbing above the fourth seam.

The figures show the position and details of the dam, which consists of 35 segments of metal weighing about 59 tons.

The shaft was filled below the level of the thill of the sixth bed of salt at a depth of 370 feet. A timber scaffold was laid at this point, covered by about 11 feet of concrete, and the centres for the dam were placed above the concrete.

The dam is in the form of a cylindrical arch, with a radius of about 12 feet, the chord or width being 14½ feet, and the length 17½ feet. It consists of seven sections, each containing five hollow cast-iron blocks, or voussoirs, the faces of whose joints

are planed, and before being bolted together are brushed over with a thin coating of mastic and linseed oil. The four surfaces, between the four abutments of the arch, in the sixth bed of salt were covered with sheets of india-rubber. The centres were removed before the central key block was placed in position and wedged with copper.

The dam was covered with a bed of quick setting cement about 2½ feet thick. The concrete was applied in thin beds of 1 to 2 yards area, about 3 inches thick in the middle and thinned towards the edges. Very little water was used with the cement applied to the sides of the pit in the rock salt, with which it united very fairly. The concrete was formed of one part of washed river sand and one part of Vassy cement, of which 17 tons were used.

The concrete is covered with about 33 feet of good clay, carefully pugged with saturated brine.

The sides of the pit were carefully dressed by the pick in order to remove any rock loosened by contact with air or water.

The work cost about £2,200.

M. W. B.

PERMEABILITY OF CEMENTS.

Results of Experiments made to determine the Permeability of Cements and Cement Mortars. By G. W. HYDE *and* W. J. SMITH, *condensed by* L. M. HAUPT. *Journal of the Franklin Institute*, 1889, *Vol.* 128, *pp.* 199-207. *One figure.*

The specimens, 3 inches thick, were tested by means of four pipes, 3 inches in diameter, joined to a 3-inches pipe, through which the pressure was communicated from a hand-pump, and maintained throughout the series at 75, 100, and 200 pounds per square inch respectively for three hours.

The experiments embraced six series, and the discharge of water through the samples was as follows :—

Samples.	No. of Samples.	Pressure per Square Inch.					
		75 lbs.		100 lbs.		200 lbs.	
		Water passed per Square Inch per 24 Hours.					
		Max. Quarts.	Min. Quarts.	Max. Quarts.	Min. Quarts.	Max. Quarts.	Min. Quarts.
Neat cement, after setting 7 days ...	5	·091	—	·092	·006	·267	·040
Do. do. 28 do. ...	1	—	·034	—	·052	—	·158
Cement mortar, 1 to 1, after setting 7 days	3	12·397	1·503	17·096	2·336	36·207	6·323
Cement mortar, 1 to 2, after setting 7 days	5	42·546	2·107	52·554	3·310	101·268	10·508
Cement mortar, 1 to 1, after setting 28 days	3	1·704	·328	2·482	·551	4·471	1·413
Cement mortar, 1 to 2, after setting 28 days	5	34·006	1·941	13·815	3·012	31·482	6·616

M. W. B.

GRISOUTITE.

Expériences faites sur la Grisoutite, les 25 *April et* 23 *Mai*, 1889, *au Charbonnage des Produits, à Flénu. By* E. LARMOYEUX. *Revue Universelle des Mines*, 1889, *Vol. viii., pp.* 239-255, *and Plate* 11.

The experiments were made in an old boiler about 48 feet long and 59 inches diameter, and ·39 inch thick. It was closed at one end with masonry containing the cannon, 27½ inches long and $15\frac{3}{8}$ inches diameter, the shot-hole being $2\frac{1}{8}$ inches diameter and 19¾ inches long. The boiler was fitted with 14 windows, 6 of which were closed with glass ¾ inch thick. There were 3 valves, near the closed end of the boiler.

A meter was used to measure the gas. 7·71 grains detonators (triple) and 15·43 grains detonators (quintuple) were used on the first and second days' trials respectively.

A coil, heated by steam, was placed in the closed end of the boiler.

Coal-dust was spread upon a plank placed 6 inches below the orifice of the shot-holes, so that the gases of the explosive should be thrown upon the dust.

In 11 experiments the end of the boiler was open, but in the remainder an iron ring ⌴ was riveted to a wing in the boiler, to which a sheet of waxed paper could be attached by means of an india-rubber band, during each experiment. By this means a closed space of about 280 cubic feet was formed, fitted with 6 windows closed with thick glass. The gas was introduced by an iron pipe into the bottom of the boiler, near the cannon, and was mixed with the air by means of an iron plate, swung to and fro, by an external lever. The valves rested upon india-rubber seats. All joints were carefully luted with thin clay. The glass windows were replaced by waxed paper on the second day.

It is with great difficulty that the gas was introduced without escape, and that a mixture of exact composition was obtained.

The explosions increased in violence as the proportion of coal-gas was increased, and for the same proportion, as the temperature increased. Explosions of gas are produced with 10 per cent. mixtures.

A short interval separated the appearance of flame at the end of the tube and that of the fumes and dust.

The results of the experiments may be tabulated as under:—

Name of Explosive.	Percentages of Coal-gas.							
	Stemmed with Coal-dust.				Stemmed with Clay.			
	0	6	10	12	0	6	10	15
Compressed powder ...	I_2	—	—	—	—	I	I_2	—
Gelatine-dynamite ...	I	—	—	—	—	—	I	—
Blasting gelatine ...	—	—	I	—	—	—	—	—
Forcite	I_2	I	I	—	N	—	N_2	I†
Grisoutite	N_4*	N	N_2	N_2	—	—	N	N†

I signifies ignition, and N non-ignition of the explosive mixtures, the small figures $_{2}$, $_{3}$, $_{4}$ indicating the number of experiments. * Crusts of coke found in the boiler. Coal-dust was placed in the boiler, in all the experiments except the two marked †.

It will be seen that all the explosives stemmed with coal-dust, gas being absent, produced flame except grisoutite. Forcite, stemmed with clay, gas being absent, did not produce flame.

In experiments with explosives care should be taken to distinguish the flame of the explosive, of the coal-gas, and of the coal-dust, which occur in rapid succession.

In all the experiments the mechanical effects produced by the explosive with coal-dust were very little more than when stemmed with clay, and much less than produced by the explosive with coal-gas.

It is not surprising that coal, a combustible, should ignite in prolonged contact with the very hot gases produced by the detonation of an explosive and make a slight addition to the mechanical effects owing to the heat developed during its combustion.

The non-explosibility of coal-dust seems demonstrated by the appearance of flames exempt from sparks at the end of the tube *followed* by black clouds of smoke and dust; without dust they were accompanied by flame. M. W. B.

THE CHALON-GUERIN GELATINIZED WATER-STEMMING.

Grisoutite et l'Eau gélatinisée. By MESSRS. V. WATTEYNE *and* E. LARMOYEUX. *Revue Universelle des Mines*, 1889, *Vol. viii., pp.* 256–269.

Messrs. Chalon and Guerin use water in a gelatinous form, in small cylinders. These cylinders contain 98 per cent. of water and 2 per cent. of gelatinous matter procured from seaweed.

It is placed at the end of a shot-hole somewhat larger in diameter than the cartridges, which are pushed in with the beater, so as to penetrate into and be surrounded by the gelatinous matter. One or more pieces of the gelatinized stemming is then pushed in, and the operation completed with clay stemming.

Trials have been made with this stemming in the mine and in the dark, and it may be presumed that the absence of the slightest glimmer would allow of the statement being made that no explosion would occur in the presence of an explosive mixture.

The following table contains the results of various trials:—

Explosive used.		Length of Clay Stemming.	Length of Glimmer or Flame observed.							
			Weight in Ounces of Gelatinized Stemming.							
Name.	Weight.		Nil.	8·4	11·3	14·1	16·9	19·0	21·1	29·6
	Ounces.	Inches.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Grisoutite... ...	6·6	12 to 20	20	—	—	—	—	—	—	—
	10·1	12 to 20	40	—	—	—	—	—	—	—
	12·7	8	—	—	—	—	—	?	—	—
	13·1	12 to 20	40	—	—	—	—	—	—	—
	16·4	8	26	—	—	—	—	—	—	—
	19·7	16 to 20	24	—	—	—	—	—	6	Nil.
	19·8	8	26	—	—	—	—	—	—	—
Forcite	6·3	8	—	—	—	—	—	26	—	—
	9·5	8	—	—	—	26	—	—	—	—
Blasting-gelatine	5·3	3	—	120	—	—	—	—	—	—
	6·0	12 to 20	—	40	40	40	—	—	—	—
	8·2	30	120	—	—	—	—	—	—	—
	9·0	8	—	—	—	—	26	26	—	—
	10·6	16 to 20	—	—	—	—	—	—	?	—

It is evident that *impressions* are subject to errors, which may be reduced by the number of witnesses.

The table shows that actual safety is not secured under any of the conditions given; with one exception, glimmers of light were seen in all the experiments.

Grisoutite has about one-third of the power of blasting-gelatine or forcite.

It will be seen that grisoutite alone is similar to forcite or blasting-gelatine, with the gelatinized stemming in point of safety.

Although the Chalon-Guerin stemming is not difficult to use, it is more difficult than grisoutite.

The cost of a charge of grisoutite is a little more than a charge of blasting-gelatine or other explosive, with the addition of the safety stemming.

The gelatinous matter costs 5s. 6d. per pound, and boiled with fifty times its weight of water cools into a gelatinous mass, which is easily cast into little cylinders of suitable dimensions.

A charge of 10½ ounces of blasting-gelatine requires 18 ounces of Chalon-Guerin stemming, hence—

Blasting-gelatine ...	10½ ounces	at 1s. 3d. per pound	=	9·84d.
Stemming	18 „	at 1½d. „	=	1·68d.
	Total			11·52d.

20 ounces of grisoutite would be required, costing, at 1s. per pound, 1s. 4d., or a difference of 4½d. in favour of the Chalon-Guerin stemming.

The writers suggest that instantaneous dry plates should be used. The camera being turned towards the orifice of the shot-hole, the cover would be removed as soon as all lights had been removed. The shot would be fired, and the glimmer would be faithfully recorded on the plates. The records would be fixed and could be reproduced to any extent, and the copies could be compared and discussed at leisure.

M. W. B.

DYNAMITE AND GRISOUTITE.

Note sur de Nouvelles Expériences faites sur la Grisoutite. By E. BRAIVE. *Revue Universelle des Mines, etc.*, 1889, *Vol. v., pp.* 67-86.

The following experiments have been made at Schlebeisch, with grisoutite, with the apparatus as described in Vol. xxxviii., Abstracts, p. 26, of the Transactions of the North of England Institute of Mining and Mechanical Engineers:—

1, 2, 3.—Experiments were made in the absence of gas and dust. Dynamite (2·65 ounces), gelatine dynamite (2·65 ounces), and grisoutite (7·95 ounces) were fired. In the first and second explosions flames were distinctly seen. No flame was seen with grisoutite, only a white cloud and water vapour.

4.—*Dynamite:* two cartridges (5·30 ounces); dry and finely screened coal-dust from Agrappe (4·41 pounds), no gas. Result, flames without explosion.

5.—*Dynamite:* 2·65 ounces enclosed in 4·41 pounds of coal-dust from Agrappe; 8 per cent. of gas; temperature, 73 degs. Fahr. Result, explosion of gas rather than coal-dust.

6.—*Dynamite:* 5·30 ounces with 4·41 pounds of dust from a New-Iserlohn; 8 per cent. of gas; temperature, 86 degs. Fahr. Result, much more violent explosion; flames 13 feet high.

7.—*Grisoutite:* 8·82 ounces with about 4·41 pounds of the same dust as used in No. 6; 8 per cent. of gas; temperature, 86 degs. Fahr. Result, neither flame nor explosion.

8.—*Dynamite:* 5·30 ounces; 4·41 pounds of dust from Boule; 12 per cent. of gas; temperature, 86 degs. Fahr. Result, very violent explosion, flames many feet high and burning for some seconds at the orifice of the cylinder; many buttons and crusts of coke in the interior of the apparatus.

9.—*Grisoutite:* 8·82 ounces; 12 per cent. of gas; temperature, 84 degs. Fahr; coal-dust from Boule. Result, neither flame nor explosion.

10.—*Dynamite:* 8·82 ounces; 4 per cent. of gas; Boule dust; temperature, 86 degs. Fahr. Result, long flames, heavy explosion.

11.—*Grisoutite:* 8·82 ounces; 16 per cent. of gas; Boule dust; temperature, 86 degs. Fahr. Result, no explosion and no flame.

12.—*Dynamite:* 5·30 ounces; 12 per cent. of gas; Agrappe dust; temperature, 84 degs. Fahr. Result, very sharp explosion, very high flames, the sheet-iron cylinder destroyed.

13.—*Grisoutite:* 8·82 ounces; 12 per cent. of gas; Agrappe dust; temperature, 93 degs. Fahr. Result, explosion.

14.—*Grisoutite:* 8·82 ounces; 12 per cent. of gas; Agrappe dust; temperature, 86 degs. Fahr. Result, neither flame nor explosion.

15.—*Grisoutite:* same conditions as the preceding, with similar result.

16.—*Grisoutite:* the same.

17.—*Grisoutite:* same conditions, except temperature, 95 degs. Fahr. Result, explosion.

18.—*Grisoutite:* 8·82 ounces; 4·41 pounds of Agrappe dust; temperature, 95 degs. Fahr. A stemming of about 4·8 inches of crystallized salt was placed above the cartridge in the hole, and the dust was spread in the ordinary manner. Result, neither flame nor explosion.

19.—*Grisoutite:* same conditions as above, with same result.

20.—*Grisoutite:* modified with extra salt; 7·05 ounces; Agrappe dust; 12 per cent. of gas; temperature, 95 degs. Fahr. Result, neither flame nor explosion.

21.—*Grisoutite:* with extra salt; same conditions as above, with same result.

22.—*Grisoutite:* the same.

Grisoutite has been tried in the mine for blasting coal and stone. It is very suitable for coal, as it does not break it small, and is similar, if not superior, to powder in its effects. In ordinary stone, grisoutite has sufficient effect in a hole ·90 inch diameter. Its power is said to be double that of compressed powder.

M. W. B.

NOTES ON PETRAGITE.

Mitteilungen über den neuen Sprengstoff "Petragit." By DR. MUCK. *Gluckauf,* 1889, *Vol. xxv., pp.* 433-435.

The new explosive, petragite, is prepared as follows:—A quantity of specially prepared molasses is nitrified by the admixture of sulphuric and nitric acids in the same proportions as are used in the preparation of nitro-glycerine. The nitrated

molasses are then washed, first in cold and then in warm water (with a little ammonia) to remove any free acid. The water is easily poured off and a quantity of wood-dust or powdered wood added, containing 52 per cent. of nitre. This mixture, when thoroughly dried, is petragite, containing equal quantities of nitrated oil of molasses and wood-dust.

The following advantages are claimed for petragite as compared with dynamite:—(1) it does not freeze; (2) its production is absolutely safe; (3) it is cheaper and equally effective; and (4) it is unaffected by concussions or by contact between metals.

Compared with roburite and other explosives free from nitro-glycerine (1) it is much cheaper; (2) it keeps better, being free from hygroscopic substances; and (3) it is more homogeneous, containing only one kind of solid matter.

It is found in practice to act with good effect in coal and rock, exploding with less shock than dynamite, and with a quieter action, more like gunpowder. No appearance of flame was noticed after the shots were fired, and the gases given off were non-injurious. A. N.

THE BOILERS EXPLOSION AT FRIEDENSHÜTTE.

Une Explosion de 22 *Chaudières a Vapeur aux hauts Fourneaux de Friedenshütte (Haute-Silésie.) By* — OLROY. 1889, *Series* 8, *Vol. xv., pp.* 5-60 *and Plate V.*

This accident has been already described in the Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. xxxviii., Abstracts, p. 25. Full details are given of the accident.

The Silesian Boiler Inspection Association state that the bad quality of the plates of the twenty oldest boilers, which singularly facilitated the rents from rivet to rivet, was the preponderating cause of the extent of the disaster. Such defective material was wholly unsuitable for a batttery of boilers working twenty-four hours daily for many years. They think that boilers Nos. 4 and 15 were destroyed by steam pressure, that No. 6 failed under the effects of an explosion of flue gases and steam pressure, and that the remainder have been thrown and displaced by the external action of the explosion of flue gases and by lateral shocks from the adjacent boilers.

The Silesian Branch of the German Society of Engineers attribute the explosion to the bad quality of the plates, and consider that the determinate cause was want of water.

The German Society of Metallurgists consider that one of the boilers may have exploded first owing to the bad rivets, plates, want of water, etc., and to have caused the destruction of the others in succession by the fracture of the main steam-pipe. They declare that the explosion should not be attributed to the flue gases.

The General Committee of the Prussian Boiler Inspection Associations are of opinion that by an unhappy combination of circumstances an explosive mixture of flue gases and air was formed in the flues and became suddenly ignited. The explosion of gases produced local fractures, etc., in the boilers, which (owing to their length, their mode of construction, and the bad quality of the plates) were readily extended, and finally the boilers themselves exploded.

Mr. Olroy is of opinion that the catastrophe must not be attributed to external action upon the boilers, that is by the explosion of a mixture of flue gases and air accumulated in the flues. It was probably due to the bad condition of the boilers, constructed of inferior plates and want of proper repairs, and the explosion of one boiler would successively cause the destruction or displacement of all the others, owing to lateral shocks and the sharp fall of pressure in their interior.

M. W. B.

THE VERPILLEUX COLLIERY EXPLOSION (ST. ETIENNE).

Le Catastrophe du Puits Verpilleux, a Saint-Etienne. Le Génie Civil, 1889, *Vol. xv., pp.* 219, 325.

L'Explosion de Grisou du Puits Verpilleux. By A. EVRARD. *Le Génie Civil, Vol. xv., pp.* 264-268, *and three figures.*

No. 13 Seam, 15 feet thick, was being worked at a depth of about 1,300 feet by longwall in two sections of about 7½ feet, the goaf being carefully packed with material sent down from bank as required.

The explosion occurred about 11·50 a.m. on July 3, 1889, in either No. 5 or 6 district at the face. The flames, hot gases, irrespirable gases, and air driven by the expansion had extended in three principal directions—to the downcast pit and to the two upcast pits. Fires were found at several points.

Charred coal and crusts of coke were found on the timber in Nos. 5 and 6 districts, and attained a maximum, at a certain radius beyond which it gradually decreased in all directions.

Notwithstanding the fact that the Jabin Pit explosion of some years ago was and is attributed to coal-dust, the cause of this explosion is attributed to fire-damp. It is thought that the gas came off very rapidly, and fouled a large and rapid current of air. This sudden issue is attributed to a slipping of the rocks and coal on a line of fault.

An earthquake occurred at 3 a.m. of the same day near the colliery and in the Pyrenees, and may have caused the slip.

It is difficult to define the mode of ignition, but it could not be an opened lamp as they are locked electrically. Matches had been found on workmen before the accident, and it is suggested that some may have fired spontaneously or from a blow. All the Marsaut lamps were found to be perfect after the accident. It is not considered probable that the gas was ignited from the spark of a pick.

M. W. B.

THE CARBONIFEROUS CONGLOMERATE OF MONS.

Le poudingue houiller (2ème notice). By J. FALY. *Annales de la Soc. Géolog. de Belgique*, 1885–86, *Vol. xiii. Mémoires, pp.* 183–196.

A detailed account is given of the occurrence of a Lower Carboniferous conglomerate in the Mons coal-field. Above this conglomerate there are 600 to 700 feet feet of beds (sandstones and shales) either barren of coal or containing only unworkable seams, and above these again are the Coal-measures proper.

O. S. E.

NOTES ON THE TOPOGRAPHY AND GEOLOGY OF THE CERRO DE PASCO, PERU.

By A. D. HODGES, Jun., M.E., *Boston, Mass. Transactions of the American Institute of Mining Engineers*, 1887–88, *Vol. xvi., pp.* 729–752. *Three maps and one section.*

A description of the geology, topography, climate, and industrial resources of the region.

The mining district of Peru is described as a belt of mountainous country running nearly the entire length of the Republic. It comprises the two ranges of the Andes, and the high table-lands between them.

To the east of this belt are the plains and valleys of the Amazon and its tributaries; to the west a narrow strip of coast from 20 to 50 miles broad. In this latter district are found salt, petroleum, enormous quantities of nitrate of soda, silver in a few localities, copper, and other minerals.

The mining belt has an average elevation of 15,000 to 16,000 feet. It contains valuable mineral deposits in all parts. Gold, silver, quicksilver, lead, and copper are found; salt and coal occur in many places; iron is also said to exist.

The Cerro de Pasco—the portion of the district specially described in the paper—lies to the north of Lake Junin or Chinchaicocha. This latter lies in a plateau encircled by the Cordilleras of the Andes, which unite to form the Knot of Pasco (*Nudo de Pasco*).

At the extreme north of the plateau an irregular circle of hills forms the basin of the Cerro. It is a series of small terraced plains, with a low central ridge, on which the town and the greater number of the mines are located. This central ridge is about 1½ miles long, ¾ mile broad, and is the "Cerro de Pasco."

The town is situated on the backbone and eastern slope of the ridge, while a series of immense quarries, or open cuts, called *Tagos*, or *Tagos abiertos*, occupy the western slope.

Mines have been worked over all parts of the ridge; many of the openings of the same occur in the yards and streets of the town.

The altitude of the town is some 14,000 feet above the sea; the population is from 7,000 to 8,000.

A railway running to Sachafamilia, 7 miles distant, connects the mines with various amalgamating works to the south.

The social accommodations and mining appliances are described as rough and primitive for the most part Mining operations carried on unsystematically for 250 years have resulted in the formation of the immense open cuts or *tajos* by the caving of the mines. These passing into and through the town limits have destroyed many buildings and threaten others.

As to the climate of the Cerro, its reputed terrible nature is said to be unfounded. No extremes of heat or cold occur, and from August, 1886, to March, 1887, the temperature ranged from 28 degs. to 64 degs. Fahr. Lowest point recorded 10 degs. Fahr. during night.

July, August, and September are the coldest, and from December to March the warmest months. Hailstorms, snow, and rain are liable to occur any time, and especially during certain seasons. It is exceptional, however, to have more than 2 inches of snow on the ground, or more than a mere skin of ice on the pools, and both disappear quickly under the sun.

Rains are prevalent from November to March.

The air is tonic and bracing, but owing to its thinness new-comers are subject to shortness of breath. There is very little wind.

Finally, it is concluded that the climate of Cerro is unusually wholesome for those with proper conveniences of life, but is trying to some constitutions.

At distances of from 8 to 10 miles, in almost any direction, a soft and pleasant climate can be reached by descending one of the steep ravines.

The climate is too cold for agricultural crops, but plenty of grass for sheep and cattle is produced.

The estimated grinding capacity of all the amalgamating works (*haciendos*) in the vicinity of the Cerro is 185,000 tons yearly. Many of these, however, are seldom or never used, and some are falling into ruins.

The rocks of the mining belt are of Jurassic and Cretaceous age.

In and around the basin of the Cerro, limestone conglomerates, limestones, andesites, slates, sandstones, and the argentiferous formation are found.

The limestone conglomerate caps the hills forming the western boundary of the basin; the limestones form the hills on the north and east, and partly on south. Veins, some of which have been worked, occur in the limestone.

Next the limestones come nearly vertical slates, and then eruptive masses and dykes of andesite containing fragments of sedimentary rocks. These latter are frequently much altered in the neighbourhood of the igneous rocks.

The argentiferous formation occurs between the limestones on the east and the andesite on the west. It forms the surface of the central ridge on which the town is built. The same has long been a geological puzzle. For convenience it is divided into (1) surface deposits, or ground above the water-level; and (2) deep deposits, or ground below the same.

(1) Consists of a highly metamorphosed and greatly oxidized material of constantly varying structure, colour, and composition. Over a large portion of the town ridge it is a hard, compact, reddish or brownish, and very quartzose cap of varying thickness.

Below this the formation is softer and more decomposed; sometimes of fragments of all sizes, loose or cemented together.

It is of all degrees of hardness and structure: earthy masses, soft clays, sugary sands, hard grey quartzite, porous matter like scoria, and rotten slate occur in a confused mixture. The smaller fragments are often arranged so as to present a slaty appearance. It is always very siliceous, and everywhere contains at least traces of silver.

Decomposition does not always proceed gradually from the surface downwards; very hard and very soft rocks often adjoin.

In some parts the silver is uniformly distributed, and in others in pockets. The metal is rarely visible, even with a glass, and when it is it occurs in native scales associated with quartz.

The following is an analysis of the surface ore :—

	Per Cent.
Silica...	72·00
Alumina	6·50
Iron peroxide	13·50
Iron protoxide	0·50
Iron sulphide	2·00
Lead carbonate	1·25
Lime (and magnesia) carbonate... ...	1·50
Manganese peroxide	0·55
Zinc (combination undetermined) ...	0·40
Copper	0·05
Arsenic	trace
Antimony	0·25
Sulphur	0·30
Silver	from traces upwards.

Below the water-level the rocks are very much less altered, but still metamorphosed to a considerable extent. Sulphides of silver, copper, and iron are common to both divisions and to the veins in the limestone.

The following is an analysis of a hard pyritic ore from the deeper deposits :—

	Per Cent.
Silica, etc.	40·05
Iron	26·63
Copper	2·73
Nickel	trace
Silver	0·13
Sulphur	26·55
Antimony	2·40
Arsenic	trace
Moisture	0·95
	99·44

Gold occurs in the merest traces, and thallium has been detected in the bullion.

The argentiferous deposit is considered to be in part metamorphosed sandstone, and in part altered clay slate and limestone. The original strata having been repeatedly tilted and altered by ejections of siliceous and metalliferous matter from below accompanying the eruptions of andesite have produced the existing formation. G. W. B.

NOTES ON THE GEOLOGY OF THE DE KAAP TRANSVAAL GOLD-FIELDS.

By W. H. FURLONGS. *The Engineering and Mining Journal (New York)*, 1890, *Vol. xlix., pp.* 287-291 *One figure and one plan.*

This paper contains a geological description of the district as a whole.

White or light red granite covers an extensive area, and is sometimes found decomposed to considerable depths. Taking the large granite area upon the south-eastern edge of which Barberton is built, as a centre, the auriferous deposits are found on three sides among the hills. The rocks of these hills are highly inclined, with a strike tangential to the edge of the granite basin, and dipping away from it at angles varying from 60 degs. to 90 degs.

The northern hills are composed of a narrow belt of schistose rocks; on the west those rocks are true schists, talcose, hornblendic, and chloritic; on the east they are argillaceous, and become true shales; on the south are, as a whole, shales, usually argillaceous, and sometimes hornblendic and chloritic.

Beds of sandstone and conglomerate are found on the south side.

Dioritic dykes are found, frequently decomposed into an unctuous red clay at the surface.

A most remarkable feature is the absence of lime and the large preponderance of silica, generally as quartz, found in and among the shales and schists, and penetrating the crevices, cracks, and pores of the eruptive rocks.

Many of these quartz deposits are auriferous, of irregular and roughly lenticular shape, found laying at intervals along the axis of their strike.

The other deposits of auriferous quartz take the form of veins, which extend for considerable distances along the line of strike.

Both these deposits are found continuous for the limited depths attained up to the present time. The associated minerals are all sulphides, and consist usually of pyrite or pyrrhotite, rarely of chalcopyrite and arsenopyrite. Galenite has been found in a few places, and sphalerite never.

These sulphides often contain 5 ounces of gold per ton; 30 to 50 ounces are not uncommon, and 760 ounces have been found in one sample.

Many argillaceous beds contain payable amounts of gold; the beds of conglomerate are frequently impregnated with pyrite, and with gold up to one ounce per ton. M. W. B.

THE GOLD-MINES OF OURO PRETO (BRAZIL).

Ouro Preto et les mines d'Or (Brésil). By PAUL FERRAND. *Le Génie Civil,* 1890, *Vol. xvi., pp.* 285-288, 303, 304, 325-327, 338-340, 355-357, 374-376, 389-390, 421-423, *and* 22 *figures; Vol. xvii., pp.* 8-10, 21-23.

Historical.—In 1572 the existence of gold was rumoured in Ouro Preto, and proof was found in 1693. Mines were opened in various parts of the district. The miners, chiefly slaves, increased to 80,000 about 1750, but decreased to 6,000 in 1820. Their objection to mining, the heavy imposts and taxes, gradually reduced the mining to its minimum.

At present only six companies are working: Saint John del Rey Mining Co. (Morro Velho and Cuiaba mines), Santa Barbara Mining Co. (Pari mines), Pitangui Mining Co., Dom Pedro North del Rey Mining Co. (Machine), Ouro Preto Mining Co. (Passagem, Raposos, Espirito Santo, and Borges mines), and Société des Mines d'Or de Faria.

Geology.—The rocks are distinguished in order of superposition as under:—

I.—Gneiss, mica-schists.

II.—Micaceous schists, schistose quartzites, argillaceous schists, "itabirites."

III.—Compact quartzites, sandstones.

The itabirites are a mixture of schistose quartz and specular iron ore.

The gold ores are found in veins and alluvial deposits.

The veins are either quartz with auriferous pyrites, or auriferous quartz. The pyrites veins are only found in the lower rocks, following the lines of stratification forming bed veins. The quartz veins are found at various horizons in the rocks. In the argillaceous schists a series of parallel veins are usually found, and the schists are impregnated with gold for limited distances.

In the friable itabirites, *jacotingas*, which are traversed by quartz veins, there are impregnations of gold to such distances that they are frequently taken for distinct deposits from the veins with which they are intimately connected.

The alluvial deposits are found in the valleys, and were formerly extensively worked.

Mining.—The methods and tools used in the working of the alluvium deposits of the river beds, edges, and surface deposits, and friable and decomposed rocks, are fully described and illustrated. M. W. B.

GOLD-WASHING AND DREDGING IN NEW ZEALAND.

Engineering and Mining Journal, 1890, *Vol. l., p.* 510.

Between the rocky bluffs, on the west and south coasts of the Middle Island, are low beaches consisting of the disintegrated bluff, the nearer the bluff the coarser the material, and on the west coast this is mixed with a quantity of drift wood.

The gold is found in layers of black titanic iron sand, inclining from the sea at an angle of 30 degs., or varying according to the depth of the wave that caused withdrawal of the lighter sand.

Numbers of men (hutters) are employed on these beaches (beach-combing). A high wind causes the sea to make a high beach of sand and stone, and succeeding tides gradually wash down the lighter particles, leaving the gold or part of it mixed with the heavier sand.

The beach-comber uses a box about 4 feet long and 2 feet wide, with an amalgamated copper plate at one end, and a trough, 4 feet by 2 feet by 2 feet, with handles

at one end and a barrow wheel at the other. He wheels his plant from patch to patch, and ascertains the payable ground with a long-handled shovel.

The trough is placed at right angles to the box, with the copper plate resting on the edge of the trough, and the box is inclined to the trough at an angle of 1 in 6. Another box, holding about 3 cubic feet of sand, is placed at the upper end, forming a hopper wherein the material is to be treated. The trough is half-filled with sea water, then the water is lifted from the trough to the hopper, and carries back part of the wash in its descent. When all the wash is out of the hopper the tailings are shovelled out of the trough, and the operation renewed. A large proportion of the gold is thus saved on a flat 2 feet square.

Dredging was introduced in the year 1887 by Mr. B. Smith. He used a Ball centrifugal pump, three-bladed, 20 inches diameter, with suction end enlarged to double area. This was placed on a pontoon 10 feet by 30 feet, and 3½ feet deep. The pump was driven by a compound engine with two cylinders, 5 inches and 9 inches diameter and 14 inches stroke. A vertical boiler was used, 5 feet by 2½ feet, with twelve 3-inches tubes. The pontoon was fitted with a crane, fitted with a Wild grab, to lift large stones and drift wood.

Mr. Wellman uses a centrifugal pump, and does not enlarge the suction end, but places a loose sleeve outside the suction, with an opening equal to the area of the suction between the pipes. This machine is doing very good work.

The beachers usually have a lagoon or creek in close proximity to the beach, where the dredgers get water; in other cases the water is led into ditches.

Bucket and ladder dredges have been tried, without financial success, on beaches.

In rivers, buckets and ladders have been more successful, being driven by side wheels, by the river current, thus saving fuel and attendance.

The deposits have a short existence although some have yielded prodigiously for a few months. M. W. B.

THE AMBER INDUSTRY IN EAST PRUSSIA.

Bernstein und Bernstein-Gewinnung. Dr. Richard Klebs. *Zur Guten Stunde, Vol. v., No.* 19.

At the beginning of the Eocene period thick forests of a gigantic species of fir tree, the *Pinites succinifer*, covered the north-east provinces of Germany and the southern bed of the Baltic, then dry. Their rosin has been preserved in the form of amber in a stratum of so-called "blue earth," consisting of the soil in which the forest grew, mixed with the detritus of the succeeding glacial period. At a somewhat later epoch similar trees grew here and there in the forests, which produced the brown coal-seams, and in these latter also amber occurs in small quantities. The peninsula of Samland, near Königsberg, was a part of the Tertiary or Eocene formation which escaped the devastation of the glacial epoch, and is the home of amber. The erosive action of the waters of the Baltic has partly laid bare the blue earth, and the coast between Danzig and Memel has been for centuries the seat of the amber industry.

In times past amber was fished from the sea. Its specific gravity being small, lumps of it, entangled in floating seaweed, were washed on shore by the north and north-west storms, and the right of fishing for it with a kind of shrimping net from boats was let to the different villages on the coast.

About twenty years ago the Königsberg firm of Messrs. Stantien & Becker, in whose hands almost the whole industry now lies, successfully employed divers to search the sea-bed further from the shore. The principal seats of these operations were the villages of Bruesterort and Palmnicken, the blue earth near the latter places forming a bank 16½ feet thick, in about 8 fathoms of water, and at from half a mile to a mile from the shore. After a time the loose pieces of amber were nearly all gathered and the diving was discontinued, but the same firm continued to win amber from the sea-bed in the Kurische Haff, and at a place further north, near the village of Schwarzort, by dredging. The bottom of the Haff was dredged to a depth of about 33 feet, at first with good results, but here also the supply in time became exhausted.

In 1872, Messrs. Stantien & Becker began mining operations at Palmnicken, and were the first in successfully working the blue earth underground. Previously attempted sinkings had been frustrated by the large quantities of water met with in the overlying strata of sand and glacial *débris.*

At an earlier date the blue earth was reached by quarrying, and the 22 fathoms of overlying strata were, at great expense, dug out and thrown into the sea. One of these quarries was now turned to good account. A drift was cut in the blue earth to a point below the intended shaft, and the water met with in sinking was let off downwards, through it, and into the quarry, to be there pumped out. On the shaft being finished, and the water in the sand stratum dammed back, the drift became unnecessary and was closed. The mine was then worked in the ordinary manner, and it now has passages of a total length of some 150 miles. In the year 1890 it employed 1,550 workmen and 100 officials, with engines of 1,300 horse-power, using about 1,200 tons of coal. The annual output was 117,000 cubic yards of blue earth, yielding 200 tons of amber, worth about £90,000.

The blue earth is mined and sent to bank very much as coal is worked. The larger pieces of amber are picked out at the face and collected in bags, at bank the earth is teemed into a large tank and softened with jets of water, and the mass thus dissolved is run off in long perforated troughs. The sandy earth falls through the holes in the trough and the lighter amber remains on the surface and is picked out with spoon-shaped nets.

The amber collected from the troughs and at the face is put into revolving barrels and washed with water and sand until its coating of earth is removed. It is then sent to the sorting hall in Königsberg, and, according to size, shape, quality, etc., is divided for the market into nearly 100 different varieties, the shades of colouring being very varied, and variously appreciated in different countries. In general, the flat pieces are manufactured into articles for smoking, the round pieces into beads and other ornaments, and the smaller pieces are used for the preparation of varnish. In the year 1890 these three classes of manufactured articles represented values of about £108,000, £7,750, and £9,500 respectively. A. R. L.

FIRELESS MINE LOCOMOTIVE.

Sur l'Application de la Locomotive a vapeur sans Foyer au Transport des Wagons dans l'Intérieur des Mines de Charbon. By CAMILLE ROLLAND. *Revue Universelle des mines, etc.*, 1889, *Vol. viii., pp.* 229-238, *and Plate* 10.

The locomotive consists of a receiver containing water heated to 400 degs. Fahr., corresponding to a pressure of about 16 atmospheres; the heating of the water being affected by steam from boilers upon the surface. The receiver has a capacity of about 20 cubic feet, which allows of a journey of 2 to $2\frac{1}{2}$ miles. The sides frames are ⎯⎯┘ shaped iron plates, fitted with round buffer end plates.

There are two pairs of driving wheels, which are coupled together and to the crank shaft. There are two cylinders placed between the ⎯⎯┘ frames, and vertically over the internal cranked shaft. The driver's cab is convenient.

It is 6 horse-power at a speed of 400 feet per minute, that of a horse being from 150 to 200 feet per minute. It weighs about 6,500 lbs., in working condition. All the mechanism can be readily examined and repaired, being placed externally. It is not more than $32\frac{1}{4}$ inches wide, for a 24-inches gauge, and the length about 10 feet. The exhaust is made at either end, at the will of the driver.

From 50 to 60 lbs. of steam are exhausted per mile, and aids in laying dust. The heat given off is less than that of the equivalent (6) number of horses and drivers which it can replace.

In case of derailment, owing to its lightness, one man with proper tools can replace it.

The cylinders are $4\frac{1}{4}$ inches diameter, and 7 inches stroke. The wheels are $17\frac{3}{4}$ inches diameter, and the axles $39\frac{1}{2}$ inches apart. The maximum pressure of steam is 100 lbs. per square inch, and a maximum pressure of 1,660 lbs. upon each piston.

The first cost of a plant for a length of 1,970 feet at a depth of 1,970 feet is:—

	£	s.	d.
Two locomotives, one in reserve	£350	0	0
Boiler with 350 square feet of heating surface and fittings ...	83	0	0
Pipes, 2 inches diameter, for 1,970 feet	75	0	0
Covering of pipes	75	0	0
Water-pipe	42	0	0
Contingencies	25	0	0
	£650	0	0

The cost of transport for 1,970 feet will be:—

Two enginemen at 2s. 11d. for 300 days...	£87	10	0
Coal ...	21	0	0
Oil, etc.	6	10	0
Maintenance and repairs ...	25	0	0
Interest and redemption of capital, 10 per cent.	65	0	0
	£205	0	0

The same work by horses would cost:—

Feeding six horses, repairs to harness, redemption, 365 days at 2s. 6d.	£273	15	0
Five drivers, 300 days at 1s. 8d. ...	125	0	0
Two horse-keepers, 365 days at 1s. 8d. ...	60	16	8
	£459	11	8

The saving being about £40 per animal replaced.

For a distance of 3,280 feet, requiring 10 horses, the cost would be:—

Ten horses, 365 days at 2s. 6d. ...	£456	5	0
Eight drivers, 300 days at 1s. 8d.	200	0	0
Two horse-keepers, 365 days at 2s. 1d. ...	76	0	10
	£732	5	10

The two locomotives being still sufficient for the work, and allowing that the cost may be £220, there is a saving of at least £50 per horse replaced.

M. W. B.

TRANSMISSION OF POWER THROUGH A BOREHOLE.

By WM. HALL. *The Colliery Engineer (U.S.)*, 1889, *Vol. ix., p.* 173.

The north slope in the Spring Hill Colliery (Nova Scotia) will ultimately be driven for a distance of 2,050 feet, dipping about 18 inches per yard; at present it has been driven about 800 feet.

A borehole 4 inches in diameter has been put down from the surface to a depth of about 600 feet, cutting the line of the north slope, at about 1,300 feet from the top. An engine and boiler are placed near the hole, and a rope is taken down the borehole, which will be used to haul the coals from the dip in extending the north slope, in advance, for a further distance of 750 feet. The coals from these workings is conveyed temporarily to the surface, through a level drift to the west slope (at the aforenamed depth of 600 feet), through which it is hoisted to the surface.

M. W. B.

IRON IN MEXICO.

By RICHARD E. CHISM. *The Engineering and Mining Journal (New York), Vol. xlvi.*, 1888, *pp.* 391–392.

The total production of iron in Mexico may be estimated as under:—

	Tons.
Durango ...	7,200
Hidalgo ...	5,000
Jalisco ...	600
Oaxaca ...	450
Guerrero ...	200
Other provinces ...	100
	13,550

About 4,500 tons are sold as castings and the remainder is wrought into bars for smiths' use.

The most important deposit of ore is the "Iron Mountain," near the city of Durango. It is an immense hill, 1 mile long, ½ mile wide, and rising at the highest points to 450 or 650 feet above the surrounding plain. The ore in *situ* is estimated at 250,000,000 tons, and is all oxides, yielding about 50 per cent. of iron in the blast furnace, and is reasonably free from phosphorus and sulphur.

The next deposit of ore in importance is that of Zimapan, in the state of Hidalgo. These ores are chiefly magnetic oxides, with 30 to 80 per cent. of iron, and very low in sulphur and phosphorus. There are six blast furnaces, four of which are in operation. The ore is worked open-cast at a cost of about 2s. per ton.

In the state of Jalisco, the chief ores found are hæmatites, with an average of 65 per cent. of iron. There are two blast furnaces. The fuel used is charcoal, costing about 20s. per ton; mining costs from 2s. to 3s. per ton.

In the state of Oaxaca extensive deposits of hæmatite and magnetite are worked in several places.

Other deposits of ore are found, of hæmatite near Salome Botello Station, on the National Railroad, about 80 miles south of Laredo, in Texas; near Monclova, on the International Railroad, about 50 miles west of the last-mentioned deposit; in the cantons of Matamoros, Galeana, and Jimenez, in Chihuahua; in the district of Leon, in the state of Guanajuato; and near the city of Culiacan, in the state of Sinaloa. M. W. B.

RULES FOR VALUATION OF IRON ORES.

By S. B. Patterson. *Engineering and Mining Journal (New York)*, 1889, *Vol. xlviii., p.* 201.

Rules for determining the relative values of iron ores containing the ordinary constituents:—

1.—*Metallic Iron.*—

(*a*) Base, less than 40 per cent. per unit iron.

40 per cent. to 44 per cent., inclusive, add ¼ cent per unit.
45 „ 49 „ „ ½ „
50 „ 54 „ „ ¾ „
55 „ 59 „ „ 1 „
60 „ 64 „ „ 1¼ cents per unit.
65 „ and upwards, add 1½ cents per unit.

No fractions of 1 per cent. to be counted.

(*b*) Taking unroasted magnetites as 100; calculate red hæmatites as 110; and brown hæmatites as 115.

2.—*Phosphorus.*—Deduct for passing Bessemer limit 25 cents per ton, and 1 cent per ton additional for every one-hundredth of 1 per cent.

3.—*Sulphur.*—Deduct 1 cent for every 2 one-hundredths of 1 per cent.

4.—*Silica.*—Offset by bases in following ratio:—

Lime.—1 per cent. offsets 1 per cent. silica.

Magnesia.—1 per cent. offsets 1½ per cent. silica.

For excess of silica above bases, as above calculated, deduct 5 cents for every 1 per cent.

5.—*Alumina.*—In doubt as to its position.

6.—*Fine Ore.*—Proportion of fine ore to coarse ore has, in some cases, a bearing on the relative values. M. W. B.

LATERAL EFFECTS OF FALLS IN MINES.

La Propagation latérale des Mouvements d'Effondrement dans les Mines. By — Villot. *Annales des Mines*, 1889, *Series* 8, *Vol. xvi., pp.* 421–426, *and Figure* 3, *Plate X.*

In this case, heavy falls, produced by the robbing and removal of pillars 33 feet square, in a 7-foot seam of coal, lying at a depth of 1,060 feet, were felt, and damage caused to houses, etc., in villages situated at distances of 2,600 yards, 3,500 yards, 4,000 yards, and 7,900 yards, situated on coal-measures. No effects were produced at distances of 3,000 yards and 3,700 where the villages were situated on older rocks forming the margins of the coal-field or basin. M. W. B.

INDEX TO VOL. I.

EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; in the case of Names, it includes both Christian Name and Surname.

Discussions and local names of coal-seams and other strata are printed in italics.

The following contractions are used :—

C. and M.C ; Chesterfield and Midland Counties Institution of Engineers.

M. ; Midland Institute of Mining and Mechanical Engineers.

N.E ; North of England Institute of Mining and Mechanical Engineers

S.S. and E.W. ; South Staffordshire and East Worcestershire Institute of Mining Engineers.

The pages marked with an asterisk (*) are placed at the beginning of the Transactions.